

THE ELECTRONICS & COMPUTER MAGAZINE

APRIL 1998  
£ 2.75

FOR  
ELECTRONICS  
AND  
COMPUTER

MONITOR RADIATION?  
USE OUR E-METER!

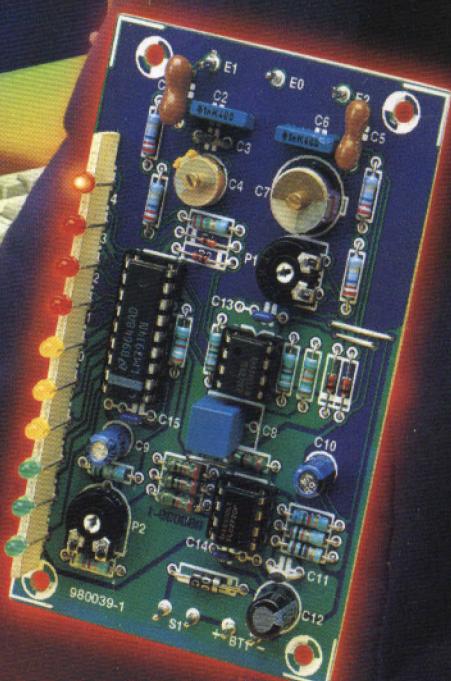
PARKING-  
DISTANCE  
MONITOR

20-METRE  
RECEIVER

FREE SUPPLEMENT  
**PC TOPICS**

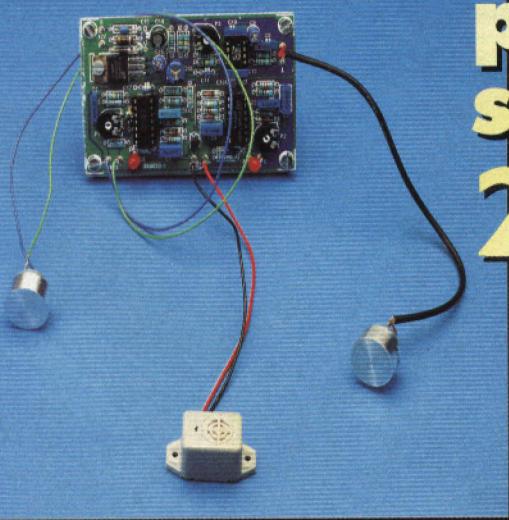
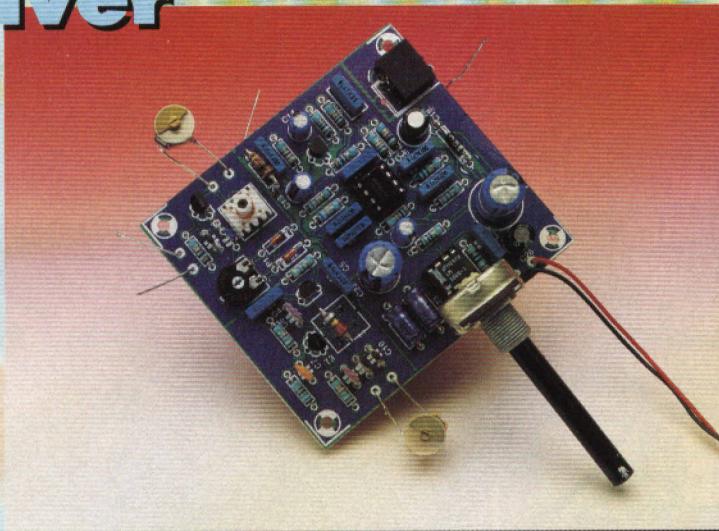
PC TOPICS  
FOLLOWS P. 38

FASTER ACCESS TO THE  
INTERNET VIA CABLE AND SATELLITE

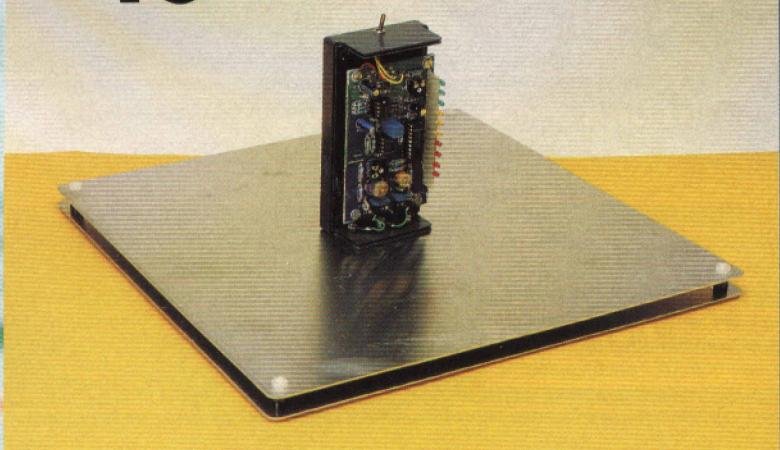


## 20 metre receiver

14



## 40 E-meter



# CONTENTS

April 1998

Volume 24

Number 265

ISSN 0268/4519

### 16-page SUPPLEMENT on **PC Topics**

Between pages 38 and 39

#### APPLICATION NOTE

##### 52 μProcessor System Hardware Monitor

A National Semiconductor  
application

#### FOCUS ON

##### 34 Digital Audio Broadcasting – Part 2

By our Editorial Staff

#### GENERAL INTEREST

##### 20 PROJECT: Parking sonar

★☆ Design by H. Bonekamp

##### 56 Introduction to Digital Signal Processing (4)

A six-part course  
by Dr. Ing. M. Ohsmann

#### RADIO & TELEVISION

##### 14 PROJECT: 20 metre receiver

★☆ Design by Eric Edwards GW8LJJ

#### TEST & MEASUREMENT

##### 26 PROJECT: PC transistor tester

★☆ Design by S. Aaltonen

##### 40 PROJECT: E-meter

★☆ Design by H. Bonekamp

##### 46 PROJECT: IC tester – Part 2

★☆ Design by L. Lamesch

#### MISCELLANEOUS INFORMATION

61 Data sheets: AD557/test vectors

11 Electronics now

66 Electronics on line: Free radio

74 Index of advertisers

17 In passing ...

39 New books

74 Next month in Elektor Electronics

68 Readers' services

60 Readers' letters: P O Box 1414

## DATA HAND IN HAND WITH POWER

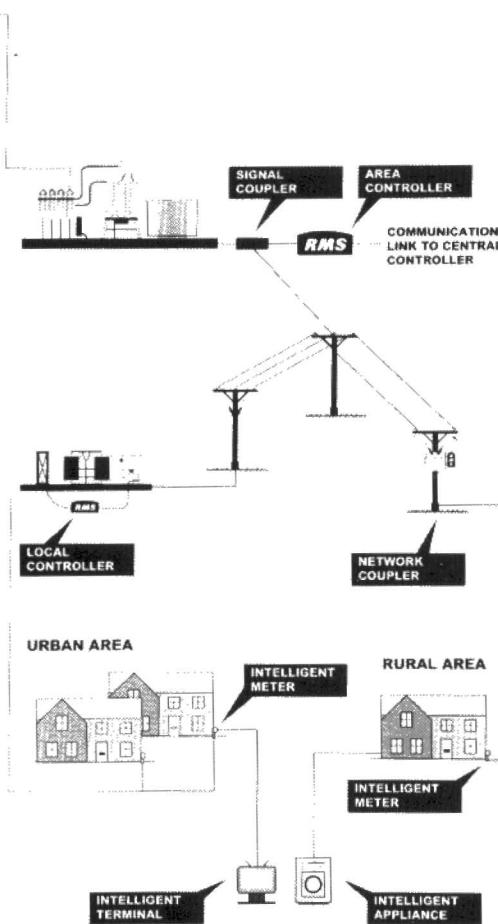
Electricity Industries around the world are undergoing radical changes in which deregulation and privatization are words of currency. With an increase in electricity suppliers and traders in the various electricity markets where complex trading and settlement procedures are used, a well-founded communications infrastructure has become a prerequisite.

In the United Kingdom, some of the large electricity suppliers soon realized that they had a ready-made vehicle for such a service. This was a power distribution network, along which, in addition to electrical power, all types of data could be channelled.

Soon after the Electricity Act, which permits the customer to have a choice of electricity supplier, was made law in the UK, one of the power generators – Scottish Hydro-Electric PLC in a joint venture with private investors – set up Remote Metering Systems Limited (RMS) in southern England in 1992 to spearhead the necessary research and development.

The company name (now changed to RMS Communication Systems Ltd) reflected the thrust of the first data application. This was to develop an advanced communications system called PowerNet that would provide a highly efficient means of transferring data between user and supplier across the existing electricity distribution network in both directions from individual devices in the home or office to central data collection points.

These collection points are sited at primary sub-stations where they are linked to area controllers. The power line



**A schematic of the Power Line Carrier system based on the British distribution system.**

**Illustration: RMS Communications.**

carrier (PLC) data path from the area controller to customer is via medium voltage (11 kV) lines to secondary sub-stations, where the step-down transformers are bypassed using non-invasive inductive couplers, and thence via low-voltage (240 V) lines to home-sited intelligent devices.

The automatic remote metering system (ARMS) developed using PowerNet enables domestic customers of any utility – or several – to monitor usage, exercise freedom of choice of supplier, enter prepayment and enjoy flexible tariffs. At the same time, the electricity suppliers can benefit from a better system of load management, fault monitoring and network automation.

The Central Controller

sited at the utility's main data processing centre communicates with each Area Controller via modems and data links, which may be either Integrated Services Digital Network (ISDN) or Public Switched Telephone Network (PSTN) or microwave. Here, the RMS data interfaces with other information technology systems, such as billing, geographic information, and the plant and assets register.

PowerNet provides for other carriers to be introduced on the data highway that can be shared by other communications services.

On the user site, a customer display terminal, which plugs simply into a domestic power socket, provides a user-friendly interface between the customer and the system by providing instantaneous information on the electricity consumption in terms of both kWh and money.

Other devices available include a configurable electricity meter (CEM) that can be programmed remotely for service as a credit or prepayment meter. An interface on the CEM enables remote metering of other, third-party, utilities, such as water. Memory is provided for consumption data.

An intelligent appliance controller is available to control which, if required, can provide diagnostics for any appliance. It can also provide limited control of electrical domestic appliances by the electricity supplier to optimize electricity usage according to a selected tariff.

Since the first commercial installation in 1997 at Perth and Fort William, plans are going ahead to include thousands more Scottish customers in this region. In Eng-

land, South Western Electricity is progressing a second two-utility pilot scheme in conjunction with a water company.

Overseas, successful pilot schemes are in train at leading electricity organizations. Two of these (PESAG and GEW) are in Germany; one is in Sweden (VB Elnat); another is in the Channel Islands (Jersey Electricity Company), and there is also a pilot scheme in New Zealand (the Bay of Plenty Electricity Company).

For other interested companies worldwide, RMS Communications has just made available a test module of its PowerNet PLC two-way communications system. This enables them to investigate and validate PowerNet's functionality and benefits in an extremely cost-effective manner and with minimum commitment of internal resources.

RMS Communications Ltd  
The Barn, Palace Gate  
High Street, Odham  
United Kingdom RG25 1JZ

### SATELLITE DISTRESS SYSTEM FOR SHIPS

A computerized information system that can alert coastguards when emergencies arise on yachts and small vessels will replace the Morse code and Mayday or SOS signals next year. The Global Maritime Distress and Safety System (GMDSS) is already in operation aboard larger vessels on the United Kingdom's southern coast and will be adopted nationally by the end of the year.

Developed by ICS Electronics and Navico, GMDSS operates automatically. After the seafarer hits an emergency button, it transmits the distress call to other vessels in the vicinity and to coastguards giving the caller's position using the satellite navigation system. It also transmits the vessel's identification number.

Up to now, GMDSS has been bulky and expensive, but the new Class-D system has won the approval of the governing European authority and costs around £300 (US\$480). The system is claimed to be better than

larger professional units because it is simple to use and includes safeguards against false alarms.

The Class-D display can also show other safety-related signals such as weather warnings and notices to sailors on such matters as changed beacons and dredging. It can also be programmed to cut out all unnecessary messages. GMDSS becomes compulsory for all ships from 1 January 1999. ICS Electronics, Unit V, Rudford Industrial Estate, Ford, Arundel, United Kingdom BN18 0AD

## 'SMART' HOUSE FOR THE DISABLED

A three-bedroomed cottage has been converted into a 'smart' house for disabled people in Barnsley, Yorkshire, at the heart of a former mining community in northern England.

The house has no steps; doors wide enough to allow wheelchairs as well as numerous operations that are controlled by button, touch or laptop keyboard. These include opening and closing windows; turning taps on and off; filling a bath to a predetermined level. Also, there are kitchen worktops at wheelchair heights, a hot-air body drier and an automatic bodily-function cleaner.

The laptop developed by Siemens is operated by touch or head movement. It emits infra-red signals to trigger a response from sensors that carry out all the tasks. These include opening and closing doors, switching lights on and off, controlling the central heating, the washing machine and microwave oven. The house, which is capable of accommodating the occupants throughout their lives, has provision for a lift and a stair-lift.

It was converted at a cost of £140,000 (\$US225,000) raised jointly by local charities, the National Health Service and The Prince's Trust. All the equipment was donated free by manufacturers.

The Joseph Rowntree Trust housing charity (based

in York) has also developed 500 homes for the disabled and elderly which feature level thresholds, downstairs lavatories, stairs that can accommodate stair-lifts, and lavatories that change into shower rooms. The homes also have light-switches and windows low enough for children to reach and kitchen units that are height-adjustable.

Rockley House Trust  
c/o Barnsley Health Authority  
Hilder House, Gawber Road  
Barnsley, South Yorkshire  
United Kingdom S75 2PY

## SPACE LIGHT SHOW ON EARTH

Scientists at University College London have 'gone one better than the Hubble space telescope' which recently produced spectacular pictures of the aurora surrounding Jupiter and Saturn. They have actually produced an aurora in the laboratory.

Aurorae are also seen on Earth as the Northern and Southern lights and are formed by the bombardment and excitation of the atmosphere by charged particles, mainly electrons, from the solar wind and from the magnetic fields of planets.

Researchers at UCL's Mullard Space Science Laboratory (MSSL) are producing aurorae in the laboratory with results that bear close resemblance to images seen on giant planets.

In a vacuum chamber, electronics from a filament are accelerated towards a charged sphere which imitates the Earth. Inside the sphere is a magnetic coil which, when turned off, produces a glow covering the whole sphere, but when switched on concentrates light towards the poles just like a real aurora.

The experiment also shows how magnetized planets are shielded from solar winds by their magnetic field which, in turn, funnel electrons into high-latitude auroral zones to create the aurora effect.

Dr Andrew Coates, who leads the aurora project at MSSL, is also the lead scientist for electron spectroscopy on the Cassini mission to Saturn. He said: "The results from this experiment will throw more light on how Saturn's aurorae form. Further questions such as why Saturn is a radio source and the reason for 'spokes' in its B ring will be answered when Cassini reaches the planet in 2004."

MSLL scientists are also involved in the United States Polar Mission, currently studying the Earth's aurorae, and Cluster, a rebuild of the European Space Agency's four spacecraft fleet to study the Earth's magnetosphere.

Dr Andrew Coates  
Mullard Space Science Laboratory  
University College London  
Gower Street, London  
United Kingdom WC1E 6BT

## TECHNO AGE PRIORITIES ARE CONSUMERS AND REGULATORS

Consumer choice and a competitive industry will be important in the Information Age, as will a sensible and logical regulating structure, according to the United Kingdom telecommunications watchdog, Ofcom.

As telephone, computer and media companies become increasingly difficult to tell apart, regulators and Government will have to react, warned Ofcom's director-general Don Cruickshank.

Ofcom has published details of the first part of its evidence to a Parliamentary select committee inquiry into developments in audio visual communications and the regulation of broadcasting.

Rapid convergence of technology, bringing together the world of computing, telephony and computing, will require appropriate responses from governments and regulators, said Mr Cruickshank.

"The European Union has already launched a debate into the competition and regulation issues caused by the rapid breaking down of barriers between broadcasting, telecoms and information technology," he said.

"The outcome of that de-

## SOME EVENTS IN APRIL

- 27 March—Effective Technical Presentation (IEEIE\*)
- 30 March—Fibre Optics for Engineers (IEEIE\*)
- 30 March—Mobile Internet 98 (IBC, phone 0171 453 2161)
- 3 April—Introduction to fibre optics (IEEIE\*)
- 7-8 April—Intranet Exposition (Blenheim Exhibitions 0181 742 2828)
- 18 April—Sams '98 Spring All Micro Show at the Bingley Hall, Staffordshire Showground, Stafford. Phone Sharon Alward at 01473 741533 for details
- 21-22 April—Wireless in the local loop (Conference, London; IBC Conferences 0171 453 2008)
- 22 April—An introduction to Internet and the Web (IEEIE\*)
- 23 April—Mobile Communications/Technologies for Mobile Satellite Services (Conference Heathrow Airport, London; Miller Freeman 0181 316 3297)

\* Phone 0171 836 3357  
Fax 0171 497 9006

To find the right computer fairs, auctions, shows, amateur radio rallies, consult the Accommodation Search Engine at <http://www.computer-fairs.co.uk>

Active Exhibitions Europe has just announced an exciting show schedule for Real-Time Computer Shows for 1998 to be held in 23 European cities and Tel Aviv.  
Details from Active Exhibitions Europe  
Phone +31 418 512 999  
Fax +31 418 540 599

bate could be new communications laws which bite on the UK. We must decide quickly what outcomes we want, so the UK can play a full part in shaping the outcome of that debate."

In launching its inquiry, the select committee has set out to explore a number of questions, ranging from the nature of technological changes affecting audio-visual communications and broadcasting, to the impact of those technological changes on the structure of communications regulation in the United Kingdom.

"These rapid developments raise questions about if, why and how the converged communications market should be regulated. Increasingly, developments in one regulator's area raises issues for other regulators."

"This has the effect of blurring boundaries which could lead to inconsistency in decisions and the risk of 'double jeopardy' for companies wishing to invest in information age service. Once Government is clear what its policy objectives are, and what special rules are needed, it can then decide the best way to enforce them."

*(Editorial comment: the less unnecessary regulation – and much of it is – the better for everybody)*

Oftel, 50 Ludgate Hill  
London  
United Kingdom EC4M 7JJ

#### NEW SECRETARY AND CE FOR IEEIE

Peter Wason has been appointed Secretary and Chief Executive of The Institution of Incorporated Engineers in Electronic, Electrical and Mechanical Engineering and will commence his duties upon the formation of the new institution this month.

Jenny Poulton  
IEEIE  
Savoy Hill House  
Savoy Hill  
London WC2R 0BS

#### PIC EMULATION GETS SMART

The latest PIC16/17 Emulator from Smart Communications (see back cover) runs at speeds up to 33 MHz and voltages down to 3 volts. The latter ability is just one of the features that sets the RICE17A apart from its competitors.

The latest RICE17A emu-

lator will support all PIC16/17 and PIC12C50x devices via interchangeable personality probes. The system includes an 8 k by 24 bit real-time trace memory and with its very competitive price starting at just £583 – this is a tool no PIC developer should be without.

Its unique design overcomes the problem with the bondout chips that require an extra instruction cycle before the I/O ports can be updated during stepping. The RICE17A updates all I/O ports instantly. In order to ensure functionality of the probes for the latest PIC17 and PIC16C6x/7x chips, a self-diagnostic test board is included which will automatically test the functional blocks of the emulator.

The new Windows 95 IDE allows users to edit, compile, and emulate, directly within the RICE17A development environment. This is compatible with all popular assemblers and compilers.

This is an extremely powerful tool that comes complete with the MPASM Assembler and both DOS and Windows software – ready to go out of the box. The RICE17A will help you to finish your PIC projects in a very short time at an amazingly competitive price.

Smart Communications are offering a 15-day test drive and can be contacted on 0181 953 9292 or on their web site <http://smartcom.co.uk>

Smart Communications  
Unit 11, Stirling Industrial Centre  
Stirling Way  
Boreham Wood  
United Kingdom WD6 2BT

#### SOURCE LEVEL SIMULATOR FROM CROSSWARE

Crossware, a UK-based embedded software tools developer, has released a new 8051 simulator that runs under Windows 95 and Windows NT4.0. The software creates a virtual 8051 microcontroller on the user's PC and provides full source level debugging facilities without the need for any 8051 hardware.

Full simulation of inter-

rupts, serial port and timers is provided, with graphic displays to show the activity of these 'on-chip' peripherals. Views of memory, registers, and disassembled instructions allow observation and control at the microcontroller level. Multiple watch windows show the values of local and global C variable and context coloured text windows allow debugging at the source code level. Multiple cycle counters indicate the number of instruction cycles that have occurred during various parts of the execution process. One of these is a trip counter that can be reset to zero by the user at any point.

A unique feature provided by the simulator is the state capture facility. A single click will capture the complete state of the microcontroller being simulated including memory contents, register values and program counter. Later, the programmer can restore this state and the simulator will reconfigure itself exactly as it was when the state was captured. All symbol watch windows, memory windows, and status displays, are updated and the programmer can restart the simulation from this restored state. Since multiple states can be captured, the state capture facility provides a means of taking giant steps both forward and backward through previously executed code without the time delay of re-executing all of the instructions between each point.

Other advanced features include source code profiling and code and data coverage.

The simulator integrates seamlessly with Crossware's Embedded Development Studio enabling users to edit, compile, link, and debug, all from within a single programmer-friendly environment. Direct feedback from embedded software programmers has indicated that integration between the simulator and the rest of the development environment is a very important issue. As Crossware is responsible for the development of all its tools, it has been able to achieve a level of integration that is unusual in the embed-

ded development industry.  
Crossware Products  
St John's Innovation Centre  
Cowley Road  
Cambridge  
United Kingdom CB4 4WS  
(see Index of Advertisers)

#### GLOBAL NAVIGATION SATELLITE SYSTEM

Unless its international partners agree to existing plans within the next few months, the European Union will give the go-ahead to the development of its own Global Navigation Satellite System. This system, which has been under consideration in Europe since 1994, is the proposed successor to the US military-controlled GPS satellite navigation network and the Russian-controlled Glonass system.

The European system will be used to provide improvements to modes of transport, particularly air traffic control, but also in applications such as support to mobile phone traffic, oil exploration, tracking dangerous goods, and providing guidance to the blind.

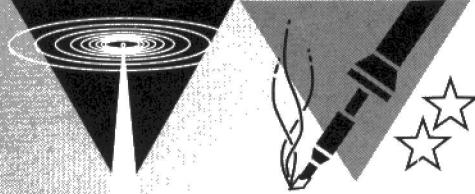
#### MAJOR NETWORK UPGRADE BY BT

British Telecom (BT) has announced a huge investment programme in high-capacity asynchronous transfer mode networks designed to cope with large surges in business Internet traffic in the next five years. It will cost £300 million (\$US480 million).

The company expect data transfer to account for 90 per cent of all corporate communications traffic by 2003. The investment will enable BT to exceed demand for these services and expand voice, data and video applications, said Chris Ernshaw, managing director of BT Networks and Systems.

"The management and exploitation of data is the key to competitive advantage. With high-speed services and applications available, the commercial opportunities for our customers are unlimited," he said.

BT Corporate Relations  
BT Centre, Room A361  
81 Newgate Street  
London EC1A 7AJ



# 20-metre SSB/CW receiver

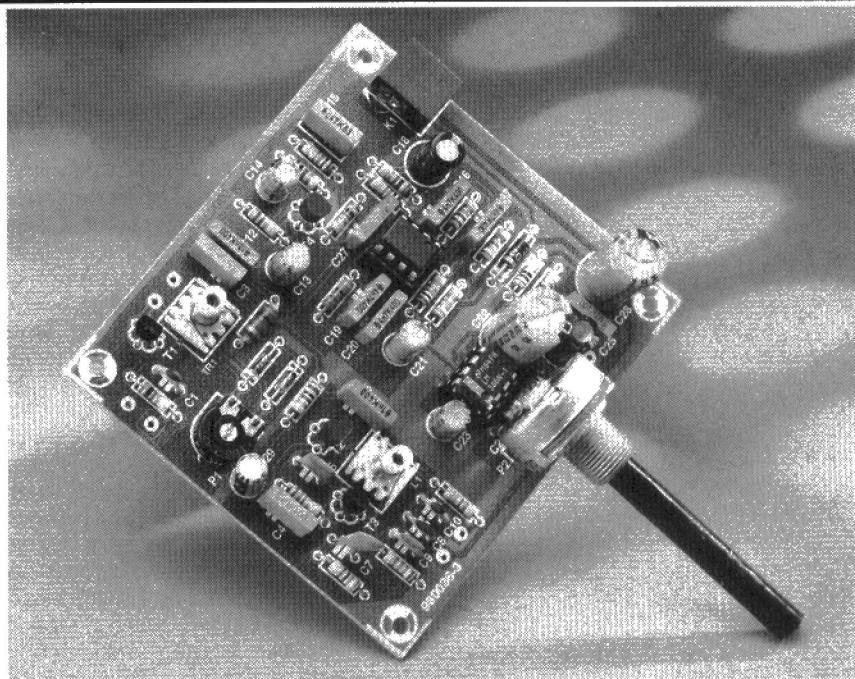
*a budget receiver  
based on direct conversion*

The receiver described here is of the Direct Conversion type and is designed for the 20-metre band

or, in new money, 14 MHz. The components used are readily available from the junk box or can be modified from standard components.

The whole idea of building simple radio projects is that they can be constructed from the bits and pieces found in the shack (a shack is a radio amateur's shed).

By Eric Edwards GW8LJJ



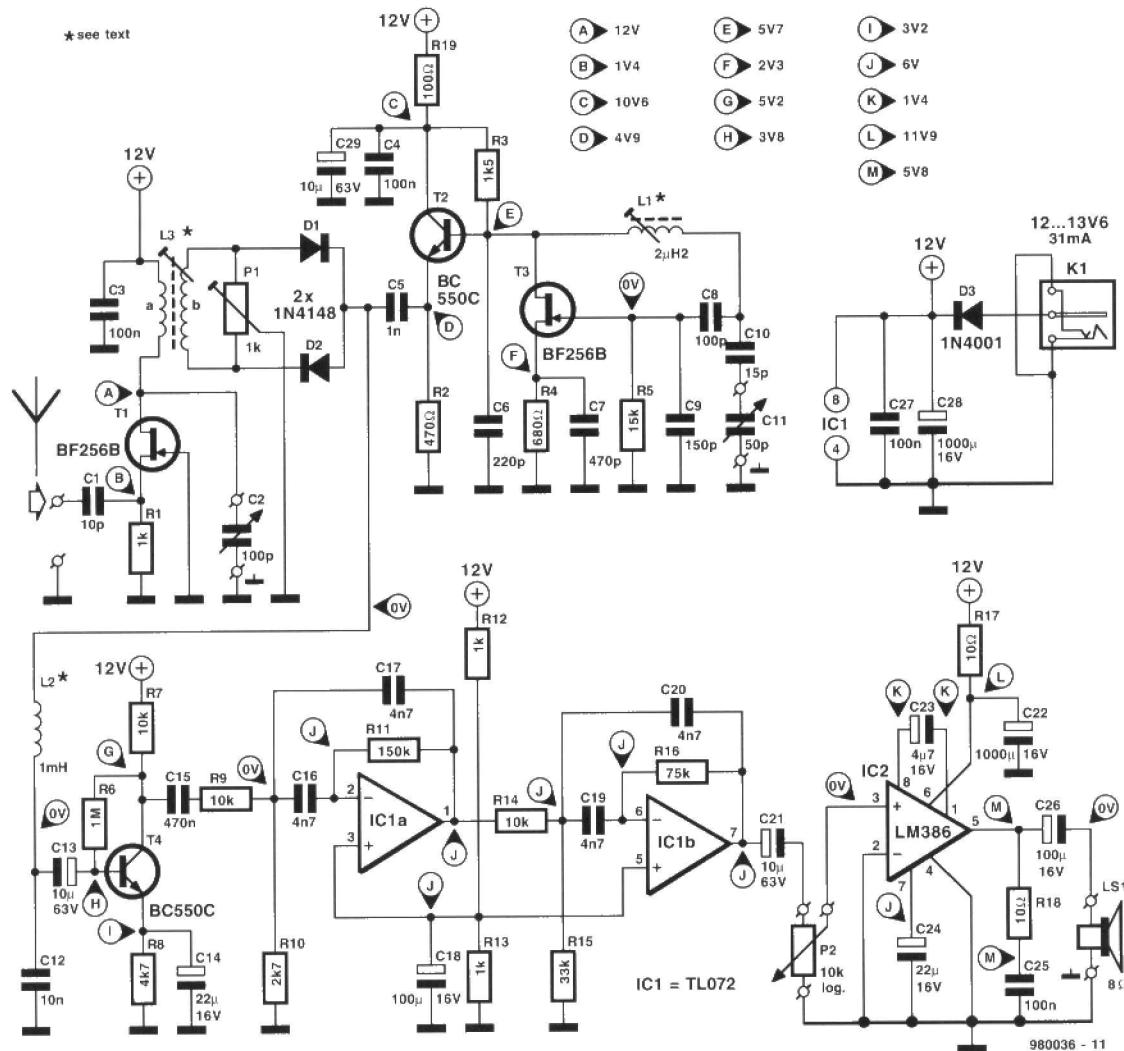
The 20-metre amateur radio band (14 MHz to 14.350 MHz in IARU Region 1) is great for daytime dxing. During periods of increased sunspot activity, the band is 'open' all the time, and the 20-m band is buzzing with activity. When there is little or no solar-flare activity, the band is still usable for medium-distance communication during daytime hours and at sunrise and sunset. Because the so-called MUF (maximum usable frequency) only exceeds 14 MHz around noon during the winter months, a fairly large skip zone has to be taken into account. Unfortunately, discussions on the intricacies of radio wave propagation and the impact of the solar cycle on radio communication are beyond the scope of this article. The good news, however, is that there are excellent books available on these subjects.

**CIRCUIT DESCRIPTION**  
The circuit diagram shown in Figure 1 may appear to be rather complicated at first blush. There are four sub-circuits.

The RF part is concerned with the receiving of the signal. It consists of two sub-circuits: **RF amplifier and filter**, T1-L3-C2, and a VFO (variable-frequency oscillator) T3-L1-C11. The **band-pass filter** around IC1 serves to clean up the received signal and make it much better to listen to. The fourth essential building block is the LM386 **audio amplifier**, which raises the cleaned signal to loudspeaker level.

Inductors L1 and L3 are home made and the two tuning capacitors in the receiver are preferably made from tuning capacitors having larger capacitance values — more about this further on.

The received signal from the aerial is fed into the source of a FET-based RF amplifier, T1, configured in grounded-gate mode to present a low impedance to the aerial. The amplified signal is tuned to the desired frequency by means of inductor L3 and variable capacitor C2. This selected output is taken to a pair of diodes wired as a balanced mixer. The other signal used for



mixing comes from the oscillator tuned by L1 and C11. This signal is tuned to very nearly the same frequency as the RF input signal. The difference is, in fact, the resultant audio output after suitable filtering. The output of the FET oscillator is buffered by a BC550C emitter follower and then fed to the diodes to be mixed with the incoming signal.

The output from the mixer diodes, D1 and D2, is first applied to an RF choke, L2, to remove the RF component from the mixer output signal, allowing the audio to pass through to the band-pass filter.

Across L3b is a preset control, P1, which may also be a good quality potentiometer fitted to the front panel still using stiff wire. It is there to suppress AM stations. Without this control, breakthrough of unwanted commercial stations will render the receiver useless. This receiver is for the reception of SSB (single sideband) and CW (continuous wave; also called Morse code), although I have also used it to receive amateur fax and slow-scan television (SSTV; very popular in the 20-m band).

The band-pass filter (BPF) built around opamps IC1a and IC1b is tuned to a centre frequency of about

2 kHz with a bandwidth of 900 Hz. It is a Butterworth 4-pole type. Basically, the filter will allow a 2-kHz signal to go

down a path 900 Hz wide to get to the audio amplifier. In this process of filtering, all the unwanted stuff is removed, including high-pitched whistles (which only your dog could hear), and low frequency hum that is only good for the older valve radio (or wireless). It also ensures all the remaining RF is removed. The filter provides the gain that is so essential to this type of receiver. The older passive type of filters using coils and capacitors introduces losses, so this design was chosen because of its advantages and easily available cheap components.

The filtered output signal goes to the top end of the volume control, P2. The wiper is taken to pin 3 of the LM386 audio output amplifier. An R-C supply decoupling network, R17-C22, provides the LM386 with a clean supply voltage.

## BUILDING THE RECEIVER

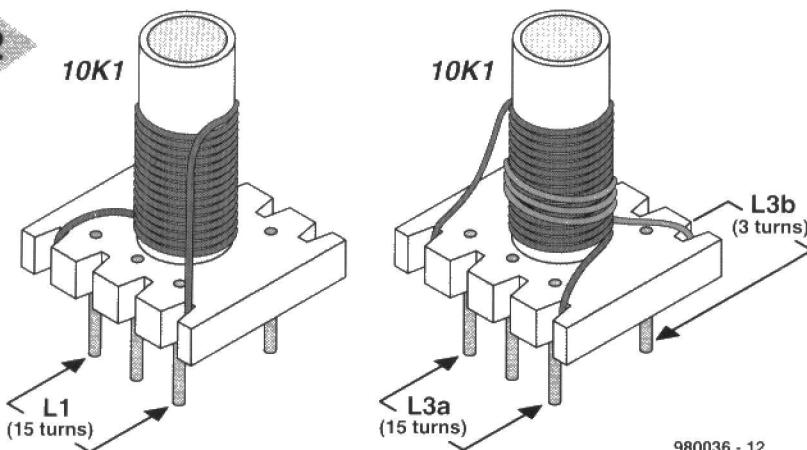
The 100-pF variable tuning capacitor, C2, may either be obtained from a

**Figure 1. Circuit diagram of the direct-conversion receiver for the 20-metre amateur radio band.**

Radio Rally (there are quite a few of these all over the country all year round), or one can be specially purchased (although the price would be pretty high).

Alternatively, get hold of a 250-pF variable capacitor as used in old radios, signal generators etc. or obtain one from a Rally if you cannot get a 100-pF at a sensible price. The vanes of these capacitors are usually crimped onto the main spindle. With a good pair of pliers, grip one of the inside vanes and tug at it until it pulls free. If whilst tugging away at one of these vanes you start to look like someone entering G-force, give up as it is probably welded (I haven't come across any that were). Remove every other until you only have half the number of vanes left. If your capacitor is of the gang type, i.e., it has more than one set of tuning vanes then you need only remove vanes from one of these sections. If you have a capacitance meter, you can at this stage check your capacitor value. It does not have to be exact because the iron dust core in the coil will adjust allowing for this. Carry out the same procedure for C11, the VFO variable capacitor, only removing more vanes to reduce the capacitor value

2



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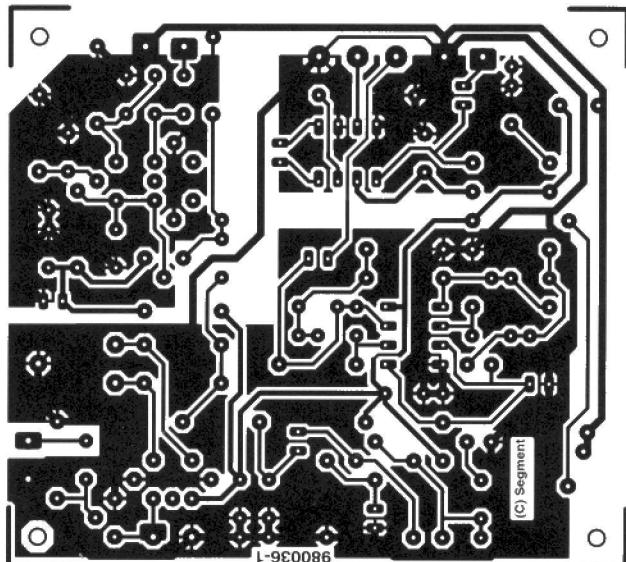
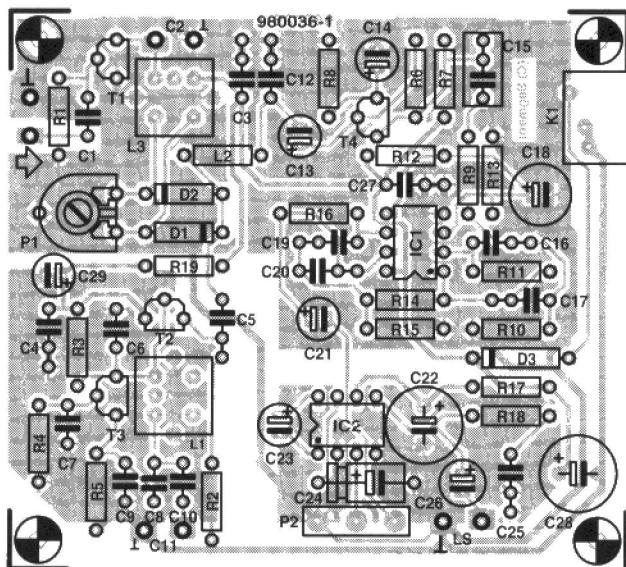
**Figure 2. Illustrating the construction of the two home-made inductors in the receiver.**

even further. C2 could be of the trimmer type providing it has a spindle to attach a control knob. Actually, the same could apply for C11 as well, providing it will allow the fitting of a slow-motion dial control. After you

have removed the vanes, check for short circuits caused by bent vanes. The tuning capacitors should be connected to the board using the shortest possible wires.

Inductors L1 and L3 are made from

3



## COMPONENTS LIST

### Resistors:

- R1,R12,R13 = 1k $\Omega$
- R2 = 470 $\Omega$
- R3 = 1k $\Omega$ 5
- R4 = 680 $\Omega$
- R5 = 15k $\Omega$
- R6 = 1M $\Omega$
- R7,R9,R14 = 10k $\Omega$
- R8 = 4k $\Omega$ 7
- R10 = 2k $\Omega$ 7
- R11 = 150k $\Omega$
- R15 = 33k $\Omega$
- R16 = 75k $\Omega$
- R17,R18 = 10 $\Omega$
- R19 = 1k $\Omega$  preset H
- P2 = 10k $\Omega$  logarithmic potentiometer

### Capacitors:

- C1 = 10pF
- C2 = 100pF variable capacitor or trimmer (see text)
- C3,C4,C25,C27 = 100nF
- C5 = 1nF
- C6 = 220pF
- C7 = 470pF
- C8 = 100pF
- C9 = 150pF
- C10 = 15pF
- C11 = 50pF variable capacitor or trimmer (see text)
- C12 = 10nF
- C13,C21,C29 = 10 $\mu$ F 63V radial
- C14 = 22 $\mu$ F 16V radial
- C15 = 470nF
- C16,C17,C19,C20 = 4nF7
- C18,C26 = 100 $\mu$ F 16V radial
- C22,C28 = 1000 $\mu$ F 16V radial
- C23 = 4 $\mu$ F7 16V radial
- C24 = 22 $\mu$ F 16V

### Inductors:

- L1 = 15 turns, 36 swg (0.2 mm dia) enamelled copper wire on Neosid 10K1 coil assembly (purple core). Alternatives: 10T1 (yellow core), 10F1 (blue core).
- L2 = 1mH choke (see text)
- L3 = primary 15 turns; secondary 3 turns, 36 swg (0.2 mm dia.) enamelled copper wire on Neosid 10K1 coil assembly. Alternatives: 10F1 and 10T1.

### Semiconductors:

- D1,D2 = 1N4148
- D3 = 1N4001
- T1,T3 = BF256B
- T2,T4 = BC550C
- IC1 = TL072CP
- IC2 = LM386N-1

### Miscellaneous:

- K1 = mains adaptor socket, PCB mount
- Printed circuit board, order code 980036-1, see Readers Services page.
- Loudspeaker, 8  $\Omega$ , 1 watt

**Figure 3. Artwork for the (single-sided) printed circuit board (board available ready-made, see Readers Services page).**

36 SWG (0.2 or 0.25 mm dia.) enamelled copper wire wound on Neosid type 10K1, 10F1 or 10T1 formers. The RF input tuning coil, L3, consists of 15 turns (L3a, primary winding) and 3 turns (secondary winding, L3b). Both are close-wound and connected to the pins of the 10K1 base as illustrated in Figure 2. An idea may be to secure the main winding, L3a, with candle wax or super-glue. When set, wind L3b in the same direction on top of and in the centre of L3a. Secure this winding and remove insulation for soldering to the base pins of the plastic former. Check the continuity of the coils at the base pins, and make sure that the screening cans may be fitted later without causing short-circuits with excess solder blobs at the pins.

The RF choke, L2, is a ready-made miniature type. It should be noted, though, that it probably gives inferior performance when compared with a real RF choke removed from some old equipment, probably because of the relatively low Q (quality) factors of those modern miniature chokes. Radio rallies and amateur radio suppliers will have these older (physically larger) types.

The audio amplifier is of a well-proven design with a chip that is economic to buy.

The printed circuit board designed for the receiver has large copper areas at the solder side to reduce stray radiation, and to enable all component leads to be kept as short as possible, which is essential to keep the circuit stable. Use a slow motion dial for the main tuning, and ensure all wiring is rigid, with the receiver built on a solid chassis or framework. Do not use a front panel that bends as you tune or you will never be able to track anyone down. Good rigid construction with neat short wiring is the secret to this good performer.

## IN USE

Set the tuning capacitors about half mesh (mid-way) and the coil cores half way down the former, adjusting with a non-metallic tool, otherwise you will be left with iron dust but no core. With the aerial and the all-important earth connected, turn the volume to about half way.

If a signal generator is available, set it to 14.20 MHz. This is centre of the 20-metre band. The output of the generator is connected to the aerial socket of the receiver, and is adjusted so that the signal is heard but not too strong. If no signal is heard and providing all is okay with your construction, tune the main tuning capacitor to bring in the signal. If still nothing is heard, you may be too much off frequency; this is easily detected by swinging the signal generator until a signal is heard. A

rewind of the VFO coil may be necessary to solve the problem. In general, however, you should not have trouble in finding the centre of the band. Right you now have the signal from the signal generator, which should be modulated to help resolve it. Reduce the size of the signal until it is just audible, adjust L3 for the strongest signal. You are now ready to try the receiver on air. Remove the signal generator and switch it off. Also switch off your computer because those things generate so much noise you will think your receiver is hyperactive. Hopefully by now you would have picked up a signal off air. Adjust C2 and C11 for the most comfortable reception together with adjustment of the volume control. If AM (Amplitude Modulation) is breaking through, carefully adjust preset P1 (across the diodes) for maximum attenuation. It works!

Throughout the preparation of this article I have been constantly listening to many DX (long-distant) amateur stations in SSB and CW, and have received some very good SSTV pictures from distant stations.

If a signal generator is not available for calibration, a general coverage or ham radio receiver could be used. Place the aerial lead of the commercial receiver near the oscillator circuit of your home-brew receiver, but not too close as to pull the oscillator of your home-brew. This is not as accurate as the signal generator but will give you an idea where you are. Once you are receiving off-air stations, these can be compared with those on the commercial receiver providing that receiver is good enough! The main tuning control does exactly what it states and the RF tune control peaks the signal to maximum. You may have to back this off for those stronger (S9+) signals...

## START LISTENING!

Enjoy building and using this little receiver, I think you will be surprised with the results.

One thing to bear in mind whether you are listening on a home-brew or commercial short wave receiver is that the reception is very much affected by the time of day/night and also the time of year. Weather and atmospheric pressure will also affect the reception. Radio amateurs use different frequency bands at different times of the year, day and night.

Finally, a directional aerial is much better than a long untuned wire, although you will receive many DX stations with a long wire aerial.

73's and good DX.

(980036-1)

## in passing ...

### A fantastic ride to nothingness?

Here at Elektor's international editorial offices we can't be alone in wondering where PC technology is racing off to. Christmas with its deluge of PC-related gifts is only just passed as I write this, and already the latest PC magazines sow the seeds of doubt: did Father Christmas on his shopping expedition choose the right PC model?

Having been with us for a decade or so, the PC seems to be on an evolutionary course which is best described as exponential. Even professional users are starting to wonder if the PC, forever subject to metamorphosis, is actually overtaking most of us mortals. Before long, any owner of a PC will have to recognize that his or her machine is obsolete the moment it is unpacked from its box, faster and cheaper models being loaded on the shelves of the computer store.

Even if you are not completely au fait with PC history, you may have noticed that 'dead-certain' developments are rare. Will USB suffer the same fate as VLB? Which of the two competing 56k6 modem standards will be elected the winner shortly? The worst cases are undoubtedly those of products that are totally incompatible with an earlier generation, for example, the future series of modems from Rockwell.

These are only a few examples of the fog looming up before unwary buyers of a new PC. Can't stop progress, you say! But isn't the information technology (IT) market on a runaway course? And who will be able to catch up with this wild ride? Before long, we will be faced with IT in three flavours:

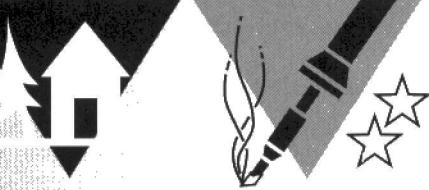
- IT for those struggling and just about managing to keep up with the almost uncontrolled evolution of products like CPUs, peripherals and software;

- IT for those who recently bought a PC and are unable to (or do not want to) follow what's happening in the PC world, not even from a distance.

- non-IT for the rest, the have-nots, unable to lay their hand on even the simplest PC because of lack of funds or the necessary infrastructure in their country. A pedal-powered PC, is it viable, like the clockwork radio?

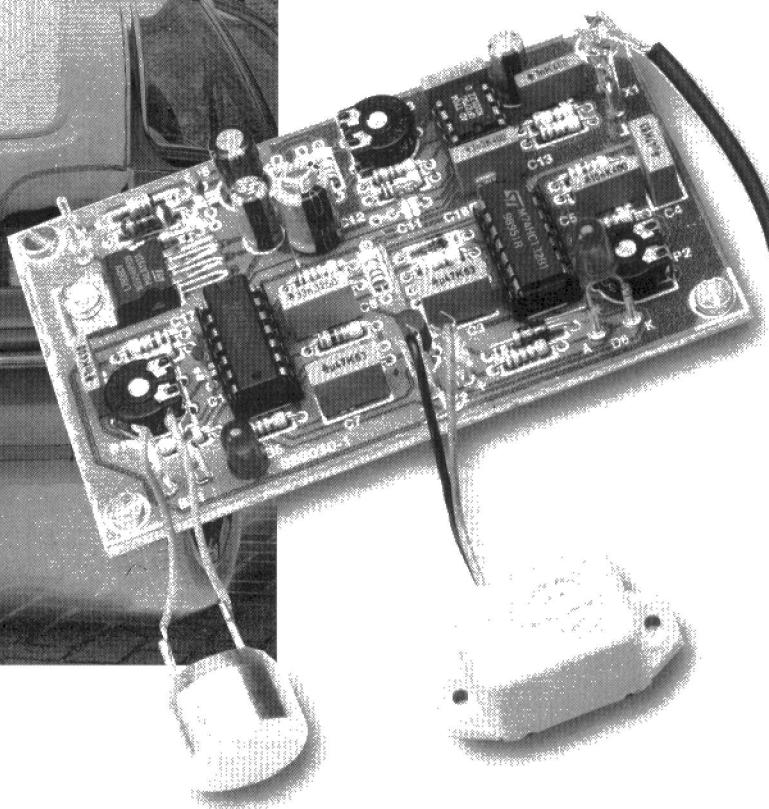
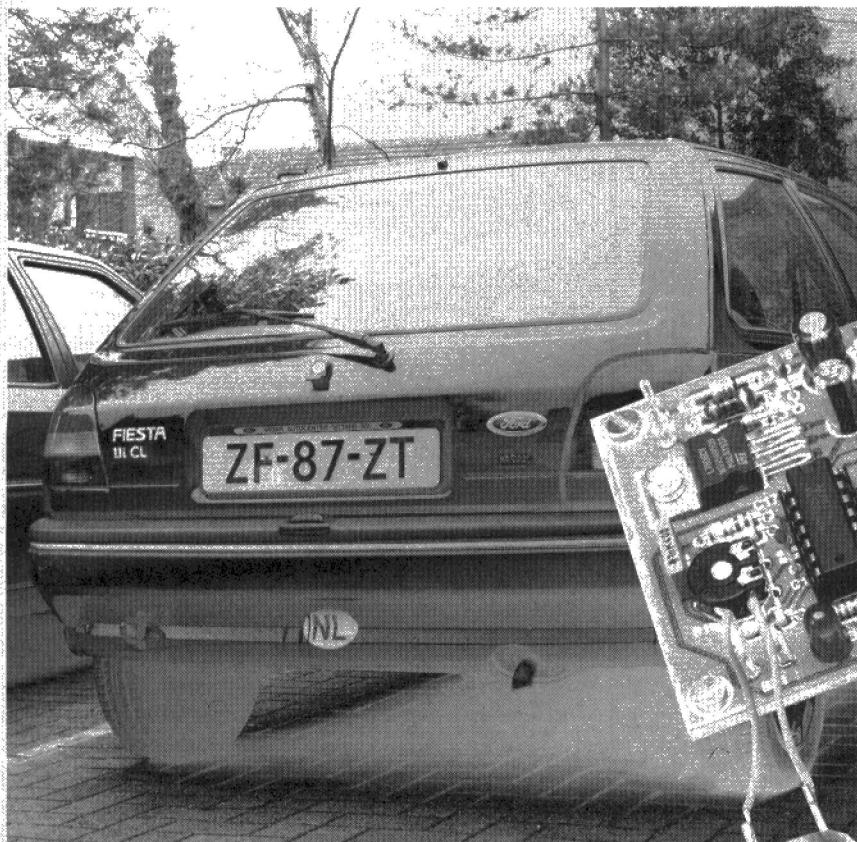
All of this is set against the background of an imminent battle between the Network Computer (NC, a closed PC without a hard disk or floppy disk) and Microsoft's Net PC, a 'great promise' according to the pundits. Although the Net PC has no extension connectors and no diskette drive, it does have an internal hard disk. Remarkably, also, Intel seems to withdraw a little from the PC industry to concentrate on digital television.

Guy Raedersdorf



# parking sonar

*range monitor  
to make parking safer*



Parking in crowded streets often causes one's car to bump into another one. Even though this normally happens at very low speeds, it should be avoided. The range monitor is an aid to 'keeping an eye' on the distance between the bumper of your car and that of the one behind you. It is a compact device that may prevent angry faces.

At some time or another, we all have to park our car in a crowded street or car park. Now, parking is something that many of us never master well and consequently tends to make us nervous. The fear is that we will bump our car into the one behind the space we have selected. An aid to warn us when we get too close to that vehicle is, therefore, very welcome.

The circuit described in this article is a fairly straightforward design that actuates an alarm when there is an obstacle at a preset distance of 30–300 cm from the bumper of a vehicle in which it is fitted. Such a distance is fine in all practical conditions. It takes over from a human 'aid' who indicates by means of hand signals how far you can reverse your car.

Design by H Bonekamp

## THE DESIGN

The range monitor is based on ultrasonic transducers: a sender and a receiver. It makes use of the natural property that sound travels through air at a virtually constant speed of  $340 \text{ m s}^{-1}$ . Any obstacle will reflect the sound emitted by the transmitter, which is then intercepted by the receiver. A measurement of the interval between the time the sound is sent and the time the echo is received enables the distance to be computed.

The block diagram of the monitor is shown in **Figure 1**. The frame generator produces rectangular pulses in a fixed rhythm. The width of the pulses determines the duration of the frame. The intervals between the pulses are long enough to prevent signal echoes from interfering with the frames.

The frames are 'modulated' by a 40 kHz signal produced by a second generator. The modulated pulses are then applied to the transmit module. The frequency of 40 kHz is not chosen randomly, but is equal to the resonance frequency of the transducer.

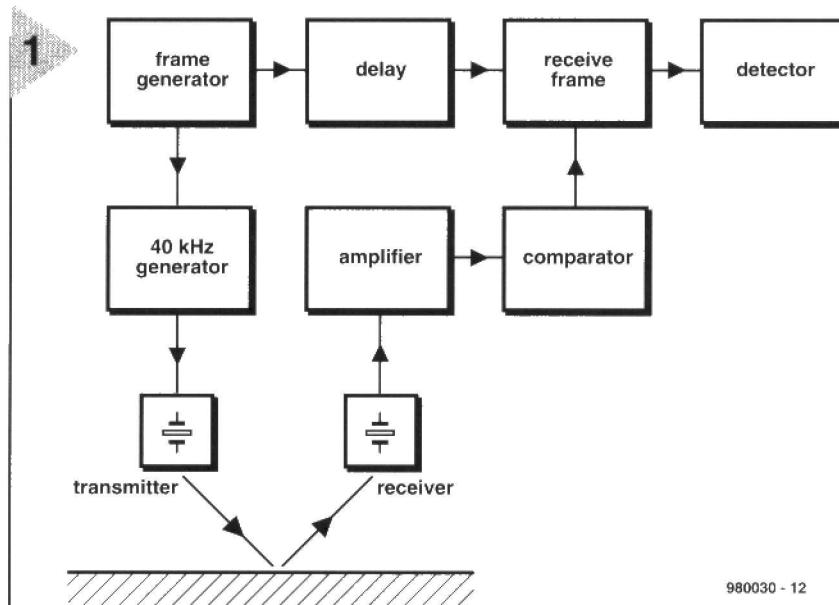
The timing diagram in **Figure 2** clarifies the process. The output of the frame generator and the signal applied to the transmit module are waveforms 1 and 2 in this diagram.

To ensure that an alarm is actuated when an obstacle is present at a certain distance, say, 50 cm, the receive frame must have some relation to the transmit frame. This is arranged by passing the output of the frame generator through a delay line and converting the consequent signal to a pulse whose width

determines the window. See signals 3 and 4 in the timing diagram. Note that only signals that fit within the window can be intercepted.

The reflected signal (or echo) is intercepted by the receiver and applied to an amplifier, which not only raises the level of the signal but also functions as band-pass filter. The resulting signal is compared with a fixed voltage: the output of the comparator is signal 5 in the timing diagram. Note that this is identical to signal 2 but shifted in time.

The detector eliminates as many spurious inputs as possible by checking the number of received 40 kHz pulses. Each receive frame should contain at least five of these pulses. If this is not so, the detector treats them as noise, whereupon a new cycle is started at the arrival of the next pulse.

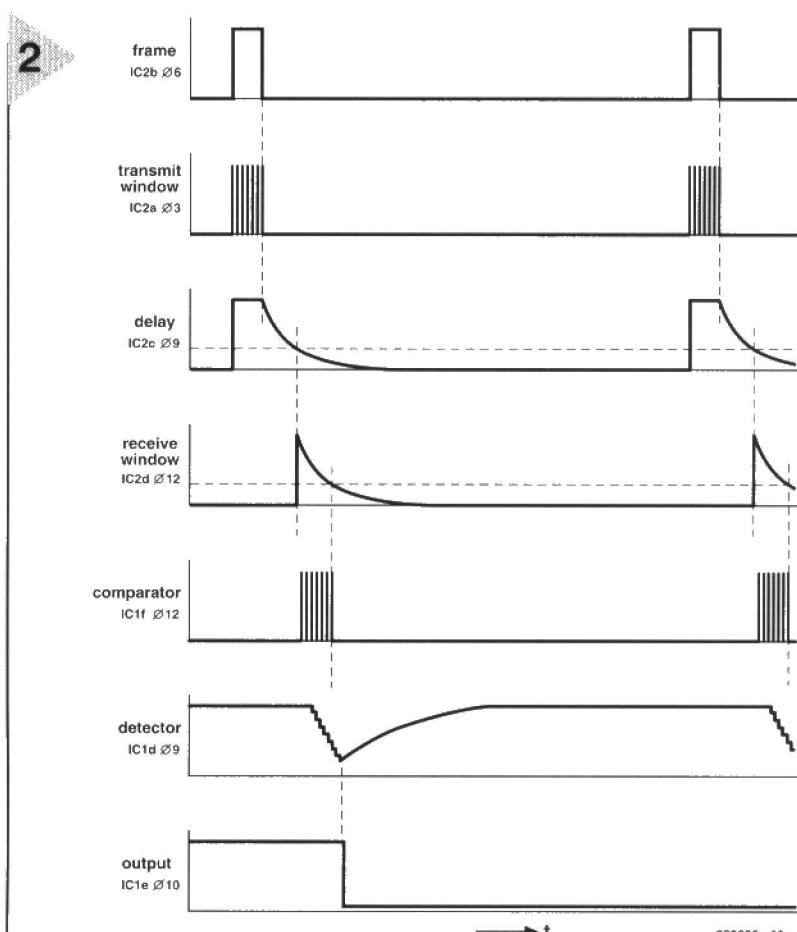


980030 - 12

**Figure 1. Block diagram of the parking sonar. The distance is computed from the time delay between the transmitted and received pulses.**

from the frame generator. Only when at least five 40 kHz pulses are detected will the output of the detector become active. The lighting of an LED and/or

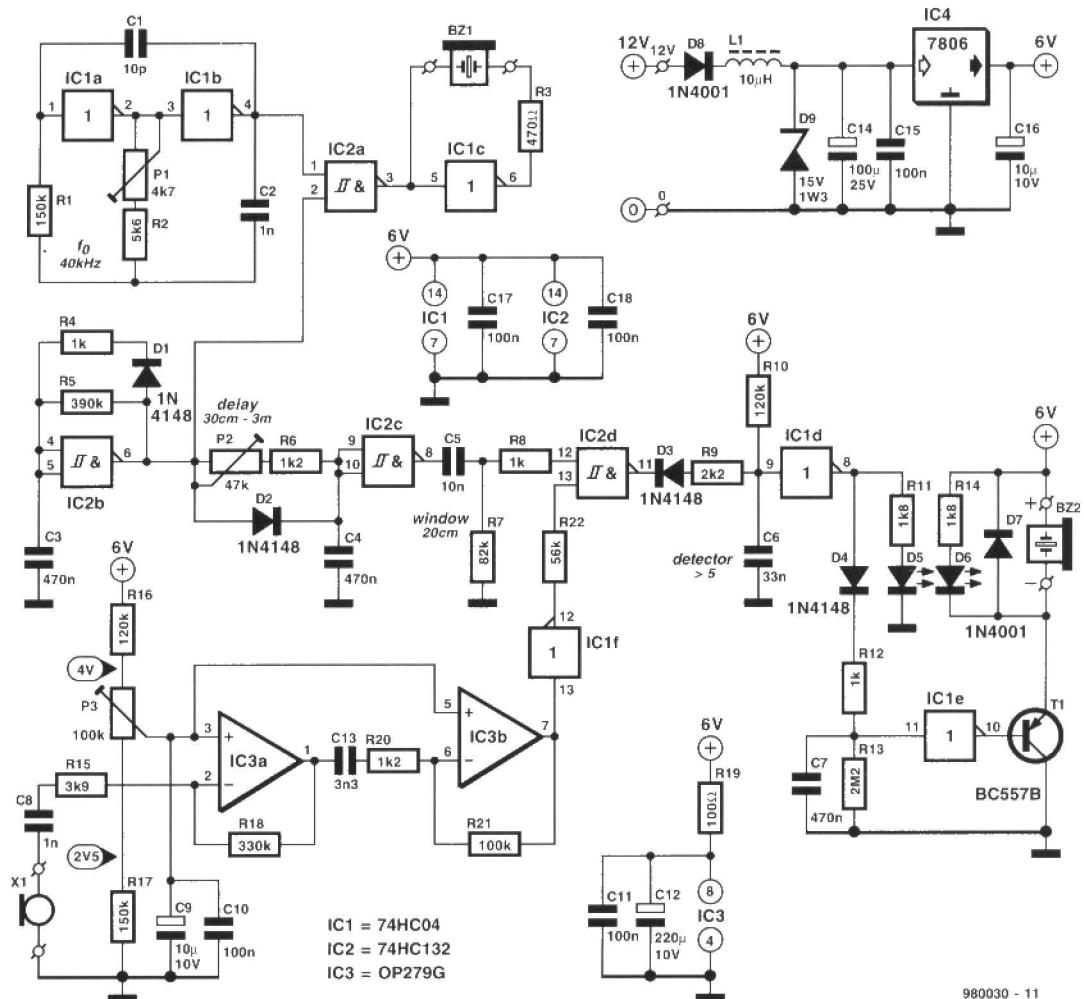
the sounding of a buzzer then indicate that the minimum set distance has been reached and that the driver should stop.



980030 - 13

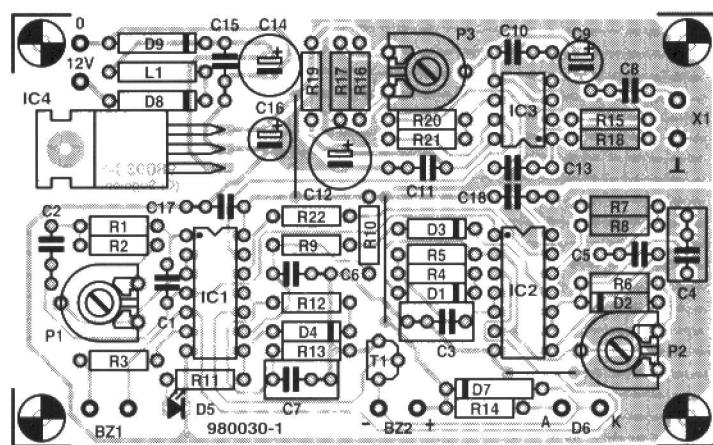
**Figure 2. Timing diagram of the parking sonar.**

3

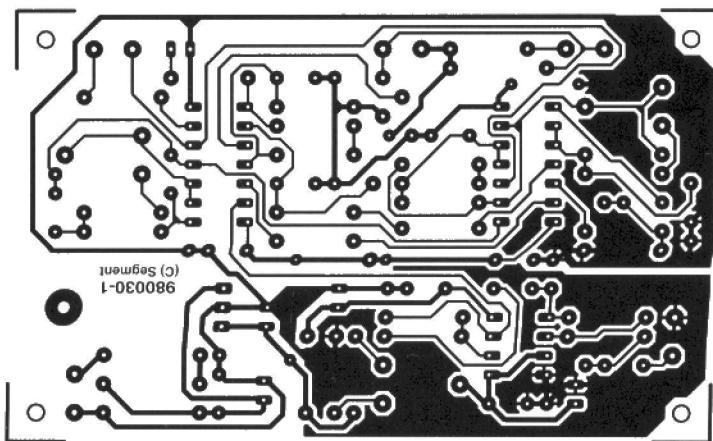


980030 - 11

4



**Figure 3.** Complete circuit diagram of the parking sonar. The transducers are  $X_1$  and  $Bz_1$ , while  $Bz_2$  and  $D_6$  are the indicator elements.



## Parts list

### Resistors:

$R_1, R_{17} = 150 \text{ k}\Omega$   
 $R_2 = 5.6 \text{ k}\Omega$   
 $R_3 = 470 \Omega$   
 $R_4, R_8, R_{12} = 1 \text{ k}\Omega$   
 $R_5 = 390 \text{ k}\Omega$   
 $R_6, R_{20} = 1.2 \text{ k}\Omega$   
 $R_7 = 82 \text{ k}\Omega$   
 $R_9 = 2.2 \text{ k}\Omega$   
 $R_{10}, R_{16} = 120 \text{ k}\Omega$   
 $R_{11}, R_{14} = 1.8 \text{ k}\Omega$   
 $R_{13} = 2.2 \text{ M}\Omega$   
 $R_{15} = 3.9 \text{ k}\Omega$

## CIRCUIT DESCRIPTION

The circuit diagram of the range monitor is shown in **Figure 3**.

The frame generator is based on gate IC<sub>2b</sub>. It is a simple oscillator that produces pulses at a frequency of about 10 Hz. Network R<sub>4</sub>-C<sub>3</sub> determines the width of the pulses and thus of the transmit frame. The pulse interval is determined by network R<sub>5</sub>-C<sub>3</sub>. The duration of each frame is equal to a period of the frame generator output.

The stability of the 40 kHz oscillator is rather better than that of the frame generator, which is why it is based on two op amps, IC<sub>1a</sub> and IC<sub>1b</sub>, and the frequency can be fine-tuned with P<sub>1</sub>.

The outputs of the two generators are combined by IC<sub>2a</sub>, which ensures that the transmit frame is modulated ('filled') with ultrasonic pulses. The resulting signal is applied to the transmit module, BZ<sub>1</sub>, via IC<sub>1c</sub> in a sort of bridge circuit.

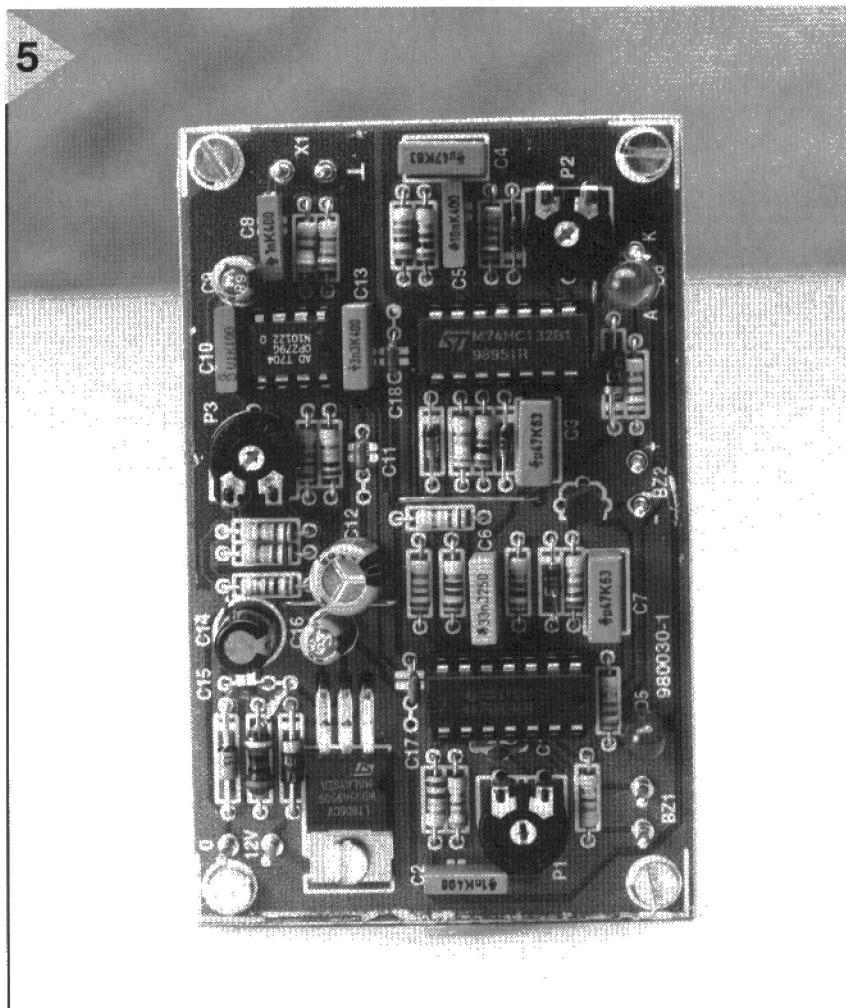
The delay line, consisting of IC<sub>2c</sub>, P<sub>2</sub>, R<sub>6</sub> and C<sub>4</sub>, is essential for the correct functioning of the monitor. The distance between transmitter and obstacle is set to between 30 cm and 3 metres with P<sub>2</sub>.

The output signal of gate IC<sub>2c</sub> is differentiated by network R<sub>7</sub>-C<sub>5</sub>, whereupon, in conjunction with the hysteresis of gate IC<sub>2d</sub>, it determines the width of the receive frame.

Resistor R<sub>8</sub> limits the current through IC<sub>2c</sub>.

The receiver module is indicated in the circuit diagram by X<sub>1</sub>. It is followed by two amplifier cum band-pass filter combinations, based on IC<sub>3a</sub> and IC<sub>3b</sub>. These op amps are arranged to give an amplification of  $\times 50$  each at 40 kHz.

Variable potential divider R<sub>16</sub>-P<sub>3</sub>-R<sub>17</sub> enables setting IC<sub>3a</sub> and IC<sub>3b</sub> to a reference voltage that ensures that inverter IC<sub>1f</sub>, which operates as a comparator, obtains the correct bias voltage. In this way, P<sub>3</sub> sets the sensitivity of the circuit. Resistor R<sub>22</sub> and



**Figure 5. Photograph of the completed prototype. Because of the small current drain, regulator IC<sub>4</sub> does not need a heat sink.**

the input capacitance of IC<sub>2d</sub>, form a low-pass filter for the comparator output.

To prevent false alarms, the output of detector IC<sub>1d</sub> can change state only when the receive frame contains at least five 40 kHz pulses. This is effected by applying the signal to network D<sub>3</sub>-R<sub>9</sub>-R<sub>10</sub>-C<sub>6</sub> after it has passed through the receive frame. This

ensures that the input voltage of IC<sub>1d</sub> will be sufficiently low to cause its output to change state only after five pulses have been received (penultimate signal in the timing diagram).

When a suitable signal is received that fits in the receive frame, a short positive pulse appears at the output of IC<sub>1d</sub>. At the same time D<sub>5</sub> lights briefly. The function of this diode is limited,

R<sub>18</sub> = 330 kΩ  
R<sub>19</sub> = 100 Ω  
R<sub>21</sub> = 100 kΩ  
R<sub>22</sub> = 56 kΩ  
P<sub>1</sub> = 4.7 kΩ preset potentiometer  
P<sub>2</sub> = 47 kΩ preset potentiometer  
P<sub>3</sub> = 100 kΩ preset potentiometer

### Capacitors:

C<sub>1</sub> = 10 pF  
C<sub>2</sub>, C<sub>8</sub> = 0.001 μF\*  
C<sub>3</sub>, C<sub>4</sub>, C<sub>7</sub> = 0.47 μF\*  
C<sub>5</sub> = 0.01 μF\*  
C<sub>6</sub> = 0.033 μF\*  
C<sub>9</sub>, C<sub>16</sub> = 10 μF, 10 V, radial

C<sub>10</sub> = 0.1 μF\*  
C<sub>11</sub>, C<sub>15</sub>, C<sub>17</sub>, C<sub>18</sub> = 0.1 μF high stability  
C<sub>12</sub> = 220 μF, 10 V, radial  
C<sub>13</sub> = 0.0033 μF\*  
C<sub>14</sub> = 100 μF, 25 V, radial

\* metallized polyester (MKT)

### Semiconductors:

D<sub>1</sub>-D<sub>4</sub> = 1N4148  
D<sub>5</sub>, D<sub>6</sub> = LED, red, low current  
D<sub>7</sub>, D<sub>8</sub> = 1N4001  
D<sub>9</sub> = zener diode, 15 V, 1.3 W  
T<sub>1</sub> = BC557B

### Integrated circuits:

IC<sub>1</sub> = 74HC04  
IC<sub>2</sub> = 74HC132 (SGS Thomson – see text)  
IC<sub>3</sub> = OP279G  
IC<sub>4</sub> = 7806

### Miscellaneous:

L<sub>1</sub> = choke, 10 μH  
BZ<sub>1</sub> = 400ET180 (Mercator)  
X<sub>1</sub> = 400ER180 (Mercator)  
BZ<sub>2</sub> = active buzzer, 5 V, <100 mA

however, to the calibration. To obtain a clear indication that a proper signal has been intercepted, the output pulse needs to be stretched and this is done by  $R_{12}$ - $C_7$ - $R_{13}$ . The stretched pulse is inverted by  $IC_{1e}$  (last signal in the timing diagram), whereupon an audible and/or an optical indication (by  $Bz_2$  and  $D_6$  respectively) are actuated.

Note that the receive frame can be widened or narrowed by adapting the value of  $R_7$  as appropriate. For most situations, however, a width of 20 cm, as in the present design, is a good practical value.

The regulator circuit based on  $IC_4$  ensures a stable 6-V power supply. Inductor  $L_1$  and diode  $D_9$  protect the supply lines against interference and overvoltage peaks.

Diode  $D_8$  provides protection against wrong polarity of the 12-V lines. Note that these lines are best taken from the reversing lights.

#### CONSTRUCTION

The monitor is best built on the printed-circuit board in Figure 4, which is, however, not available ready-made. Populating the board should not cause any undue difficulties. Note that it is advisable to use a 74HC132

( $IC_{2e}$ ) from SGS-Thomson since other makes may have a different hysteresis.

With the exception of the transducers, the indicator diode and the buzzer, all components are housed on the board.

To minimize any interference, it is essential that the monitor is housed in a properly earthed metal enclosure. The transmit and receive modules should be mounted at some distance from each other, preferably in or near the rear bumper or, in older cars, the rear spoiler. They must, of course, point in a direction immediately behind the vehicle. The transducers must be linked to the monitor (terminals  $X_1$  and  $Bz_1$ ) via lengths of screened cable (twin-core in case of the transmitter). The screens must be connected to the supply line earth.

It is advisable to keep the lines to the transmit module as far away as possible from the input amplifier to prevent transmit pulses being injected directly into the receiver.

Note that the case of the transmit module is connected internally to one of the terminals; it is, therefore, essential that the module is isolated from the monitor enclosure and/or the car chassis.

The transducers specified in the part list are both watertight.

The indicator diode and/or buzzer should, of course, be placed near the driver, for instance, in or near the instrument panel.

#### CALIBRATION

When the monitor is switched on, it will be active for about a second, which is the time needed by  $C_9$  to get fully charged. No attempt has been made to eradicate this power-on indication since it tells the driver that the monitor is operating.

The three preset potentiometers are adjusted with the aid of a good multimeter.

1. Set the multimeter to an appropriate alternating voltage range and connect it across  $R_3$ . Short-circuit  $C_3$  with a length of circuit wire. Turn  $P_1$  until the meter reading is a maximum. Seal the preset with some nail varnish and remove the short-circuit from  $C_3$ .
2. Short-circuit terminals  $X_1$  and turn  $P_3$  until diode  $D_5$  just goes out.
3. Place an obstacle at the desired distance from the rear bumper and adjust  $P_2$  until diode  $D_5$  begins to flash.

[980030]

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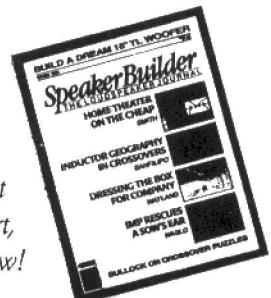
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# PC-aided BJT tester revisited

*now with Windows  
software*

The tester presented in this article is an update of the design published in our September 1993 issue.

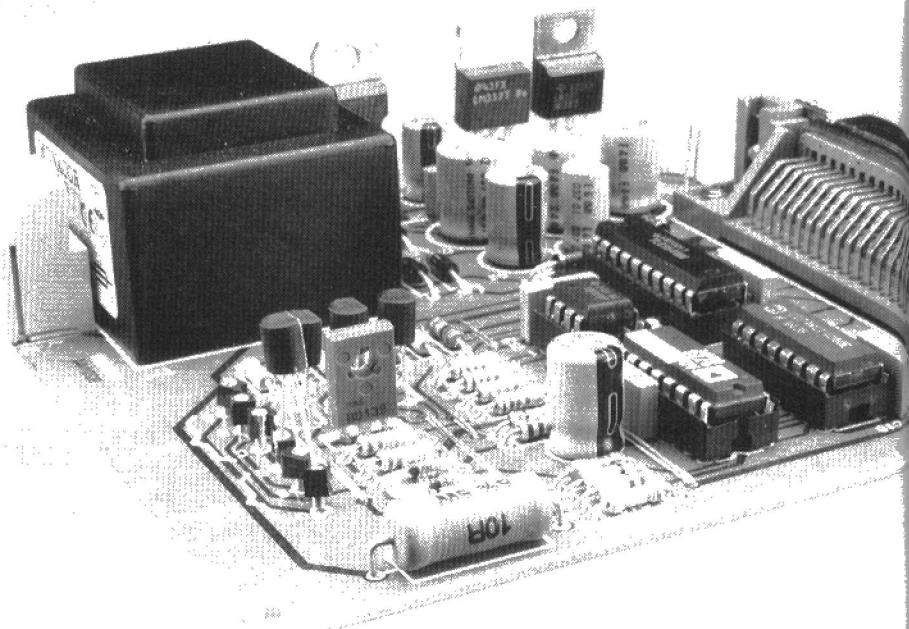
The ZN425 then used for the digital-to-analogue converter (DAC) is replaced by the currently more easily available AD557. Also, the

1993 DOS-version of the software has been replaced by a 32-bit program that runs only under Windows 95 or Windows 3.1 with a Win32S extension.

## Features

- ◊ Suitable for n-p-n and p-n-p bipolar junction transistors (BJTs)
- ◊ To be connected to parallel printer port of a PC
- ◊ Graphic display of transistor characteristics (on PC monitor)
- ◊ Integral power supply
- ◊ Windows software\*
- ◊ Test range of  $U_{CE} = 0\text{--}9\text{ V}$
- ◊  $I_C$  measured at seven base currents varying from  $0\text{ }\mu\text{A}$  to  $175\text{ }\mu\text{A}$
- ◊ Maximum measurable  $h_{FE} = 570$

\* Suitable for Windows 95 or Windows 3.1 with Win32S extension.  
The earlier DOS version of the software is also still available.



Measuring the direct-current gain  $h_{FE}$  or  $\beta$ , of a bipolar junction transistor (BJT), p-n-p as well as n-p-n, is, in principle, fairly simple. It is done by passing an accurately known direct current,  $I_B$ , through the base-emitter junction and measuring the collector current,  $I_C$ . The ratio of the two is the current gain, that is,  $I_C/I_B = h_{FE} = \beta$ . It is important to note that  $h_{FE}$  depends on the collector current, the collector-to-emitter voltage,  $U_{CE}$ , and the temperature. This means that a small base current is associated with a smaller  $h_{FE}$  than a large base current. This is the reason that a transistor is usually accompanied by a set of gain characteristics. It is clear that to obtain a good idea of the operation of a BJT, a number of base currents should be used in the tests. The circuit described in this article uses seven different base currents, varying from  $25\text{ }\mu\text{A}$  to  $175\text{ }\mu\text{A}$ . For each of these currents,  $U_{CE}$  varies from  $0\text{ V}$  to  $9\text{ V}$  in 256 steps.

Design by S. Aaltonen

## THE DESIGN

The block diagram of the tester is shown in **Figure 1**. The Centronics interface in the diagram is linked to the printer port of the computer. Six data lines of this port are used for controlling the counter and the ADC, while a handshake line (input) is used to read back the serial data from the ADC. Clearly, the data transfer between tester and computer is the same as that between a computer and a printer; moreover, any type of printer port may be used: standard Centronics, Enhanced Parallel Port (EPP) or Extended Capabilities Port (ECP).

The tester is based on an 11-bit counter, IC<sub>1</sub>. This chip, which itself is driven by two lines from the printer port, controls a large part of the circuit. During a complete test cycle, it counts from 0 to 2047. The first eight bits (LSBs) are used to drive IC<sub>2</sub>, a DAC which generates the collector-emitter voltage, U<sub>CE</sub>. The remaining three bits (MSBs) set the base current in steps of 25 µA between 0 µA and 175 µA. During the test, the U<sub>CE</sub> rises from 0 V to 9 V in 256 steps.

To display the transistor characteristics on the monitor screen, I<sub>C</sub> and U<sub>CE</sub> need to be measured, and this is done with the earlier mentioned ADC. Note that only the first quadrant is used since this gives all the necessary information for most applications.

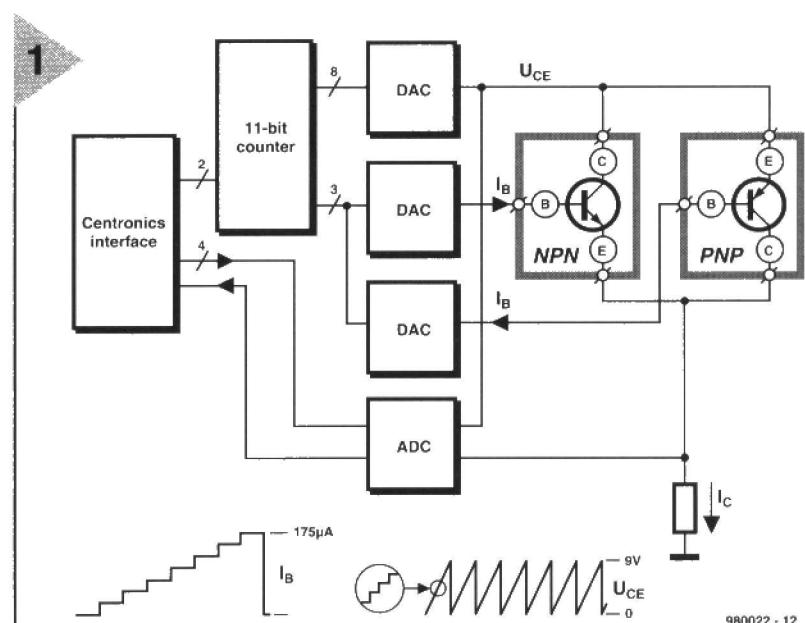
A close look at the block diagram reveals that in case of an n-p-n BJT the emitter current, I<sub>E</sub>, is measured, and in an p-n-p transistor, the collector current, I<sub>C</sub>. However, this is easily corrected (automatically by the software), since I<sub>C</sub> = I<sub>E</sub> - I<sub>B</sub>.

## CIRCUIT DESCRIPTION

The circuit in **Figure 3** is largely identical to that of the 1993 tester: the only real change is the substitution of an AD557 for a ZN425 in the IC<sub>2</sub> position.

The U<sub>CE</sub> for the transistor on test is generated by digital-to-analogue converter IC<sub>2</sub>, amplifier IC<sub>3a</sub> and driver T<sub>1</sub>.

The DACs generating the various base currents are discrete designs. The base currents for the n-p-n transistor on test are produced in a simple manner: resistors R<sub>8</sub>-R<sub>11</sub> convert the logic level (5 V) of the three MSBs output by



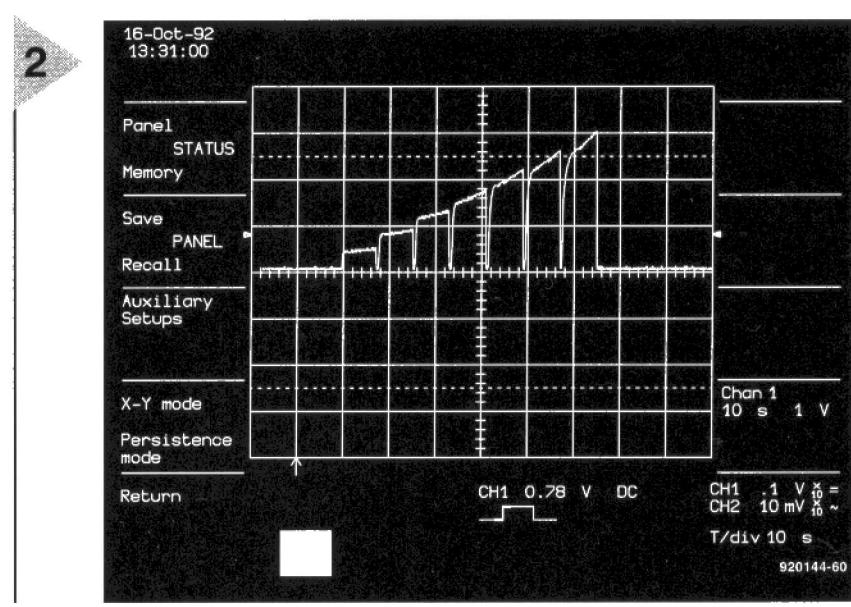
**Figure 1. Block dia-**  
**gram of the BJT**  
**tester. Apart from the**  
**interface and counter,**  
**the tester comprises**  
**three DACs and one**  
**ADC.**

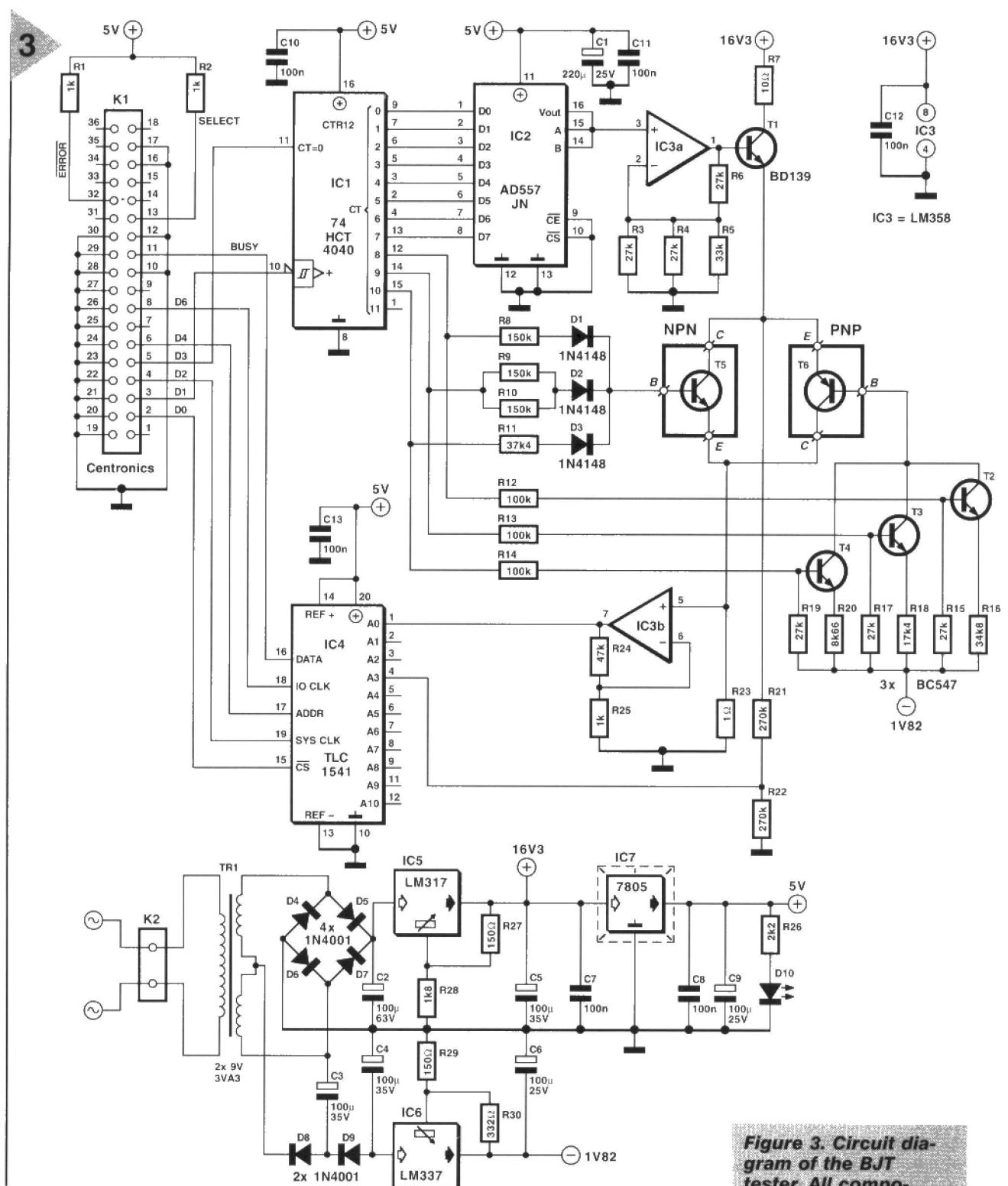
the 11-bit counter directly into a base current. Diodes D<sub>1</sub>-D<sub>3</sub> ensure that a low-level output bit cannot draw current from the base current.

In case of a p-n-p transistor on test, matters are slightly more complex, because the emitter is not at ground level, but follows U<sub>CE</sub>. To make certain that the transistor can switch on at low U<sub>CE</sub> (about 0 V), it needs to be possible to pull the base to a negative potential. This is why a negative supply line is created with R<sub>12</sub>-R<sub>20</sub> and T<sub>2</sub>-T<sub>4</sub>. The transistors and relevant resistors form current sources that are switched via the three MSBs output by the counter. In a p-n-p transistor, the base current is equal to the sum of the currents produced by the sources.

The resistance across which I<sub>C</sub> (in case of an n-p-n transistor, I<sub>E</sub>) is measured is R<sub>23</sub>. To minimize the effect of this component on the test setup, its

**Figure 2. This oscillo-**  
**gram shows which**  
**signal at input A<sub>0</sub> is**  
**applied to the ADC.**  
**Each pulse represents**  
**a different base cur-**  
**rent. The slanting side**  
**at the top shows the**  
**effect of a varying U<sub>CE</sub>.**





**Figure 3.** Circuit diagram of the BJT tester. All components are readily available types.

value is low. This has the drawback, however, that the drop across it, that is, the test voltage, is very small. It is therefore raised  $\times 48$  by IC<sub>3b</sub>, before it is applied to digital-to-analogue converter IC<sub>4</sub>.

The resulting signal to input  $A_0$  of the ADC is shown in Figure 2. This indicates that with seven base currents a voltage proportional to  $I_C$  (in of an n-p-n device,  $I_E$ ) is measured. The reason that the current rises in the course of time, although the base current is

stable, is that  $U_{CE}$  is increased from 0 V to 9 V in 256 steps during the test period. This shows the effect of  $U_{CE}$  on the current gain.

The test value is limited because the measurement range of the ADC is only 5 V. Given a voltage amplification of  $\times 48$  and a test resistance of  $1\ \Omega$ , it is clear that  $I_C$  (or  $I_F$ ) cannot exceed 104.2 mA. Since the base current is 175  $\mu$ A maximum, the current gain cannot be higher than  $\times 595$ .

In practice, the measured  $U_{CE}$  lies

between 0 V and 9 V. This value is brought to the requisite level by attenuator  $R_{21}$ - $R_{22}$ . The resulting signal is applied to input  $A_3$  of the ADC.

The power supply is straightforward based on a traditional design. Only the auxiliary negative line is a little out of the ordinary. An alternating current flows through  $C_3$ : one half cycle via  $D_8$  and the other half via  $D_9$ . Each of the half cycles charges  $C_4$ ; the resulting potential across this capacitor is held at a level of -1.8 V by  $IC_{6d}$ .

#### Parts list

##### Resistors:

R<sub>1</sub>, R<sub>2</sub>, R<sub>25</sub> = 1 kΩ  
 R<sub>3</sub>, R<sub>4</sub>, R<sub>6</sub>, R<sub>15</sub>, R<sub>17</sub>, R<sub>19</sub> = 27 kΩ  
 R<sub>5</sub> = 33 kΩ  
 R<sub>7</sub> = 10 Ω, 5 W  
 R<sub>8</sub>-R<sub>10</sub> = 150 kΩ  
 R<sub>11</sub> = 37.4 kΩ, 1%  
 R<sub>12</sub>-R<sub>14</sub> = 100 kΩ  
 R<sub>16</sub> = 34.8 kΩ, 1%  
 R<sub>18</sub> = 17.4 kΩ, 1%  
 R<sub>20</sub> = 8.66 kΩ, 1%  
 R<sub>21</sub>, R<sub>22</sub> = 270 kΩ  
 R<sub>23</sub> = 1.00 Ω, 1%  
 R<sub>24</sub> = 47 kΩ  
 R<sub>26</sub> = 2.2 kΩ  
 R<sub>27</sub>, R<sub>29</sub> = 150 Ω  
 R<sub>28</sub> = 1.8 kΩ  
 R<sub>30</sub> = 332 Ω, 1%

##### Capacitors:

C<sub>1</sub> = 220 μF, 25 V, radial  
 C<sub>2</sub> = 100 μF, 63 V, radial  
 C<sub>3</sub>-C<sub>5</sub> = 100 μF, 35 V, radial  
 C<sub>6</sub>, C<sub>9</sub> = 100 μF, 25 V, radial  
 C<sub>7</sub>, C<sub>8</sub>, C<sub>10</sub>-C<sub>13</sub> = 0.1 μF

##### Semiconductors:

D<sub>1</sub>-D<sub>3</sub> = 1N4148  
 D<sub>4</sub>-D<sub>9</sub> = 1N4001  
 D<sub>10</sub> = LED, high efficiency  
 T<sub>1</sub> = BD139  
 T<sub>2</sub>-T<sub>4</sub> = BC547B  
 T<sub>5</sub> = n-p-n transistor on test  
 T<sub>6</sub> = p-n-p transistor on test

##### Integrated Circuits:

IC<sub>1</sub> = 74HCT4040  
 IC<sub>2</sub> = AD557JN  
 IC<sub>3</sub> = LM358  
 IC<sub>4</sub> = TLC1541IN  
 IC<sub>5</sub> = LM317 (SOT220)  
 IC<sub>6</sub> = LM337 (SOT220)  
 IC<sub>7</sub> = 7805

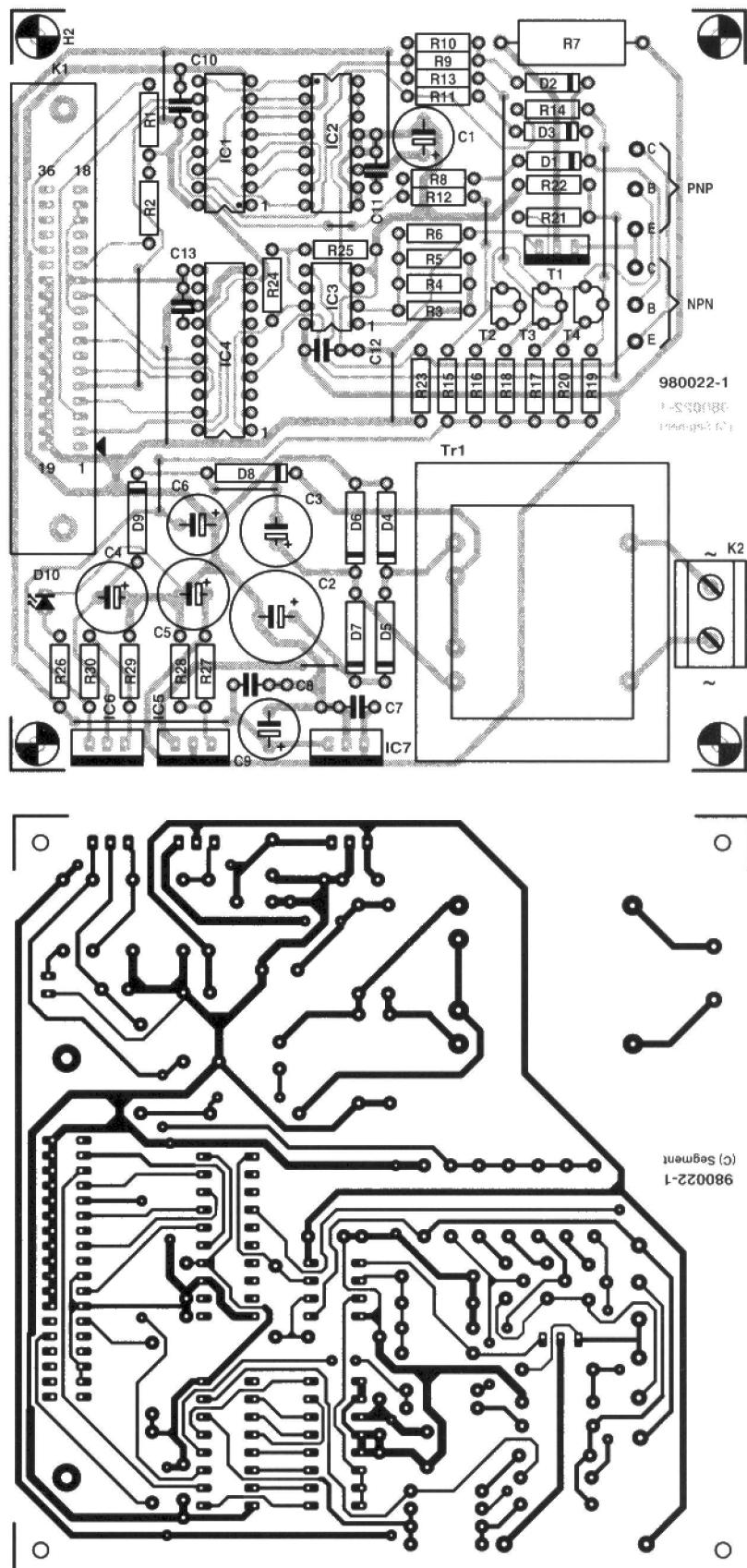
##### Miscellaneous:

K<sub>1</sub> = 36-way Centronics socket,  
 right-angled, for board mounting  
 K<sub>2</sub> = 2-way terminal block for board  
 mounting, pitch 7.5 mm  
 Mains socket with integral fuse  
 holder and fuse (200 mA slow  
 blow)  
 2 off 2 mm banana socket, blue (c)  
 2 off 2 mm banana socket, black (b)  
 2 off 2 mm banana socket, red (e)  
 DPDT mains on/off switch  
 Mains transformer 2×9 V, 3.3 VA,  
 e.g., Monacor/Monarch VTR3209  
 Enclosure 115×50×135 mm  
 (4.53"×2"×5.32"), e.g., ESM  
 EB11/05)  
 PCB Order no 980022\*

Software Order No. 986005-1\* (The  
 DOS version of the software is still  
 available under Order no. 920144)

\* These items are available as a single item under Order no. 980022-C

4



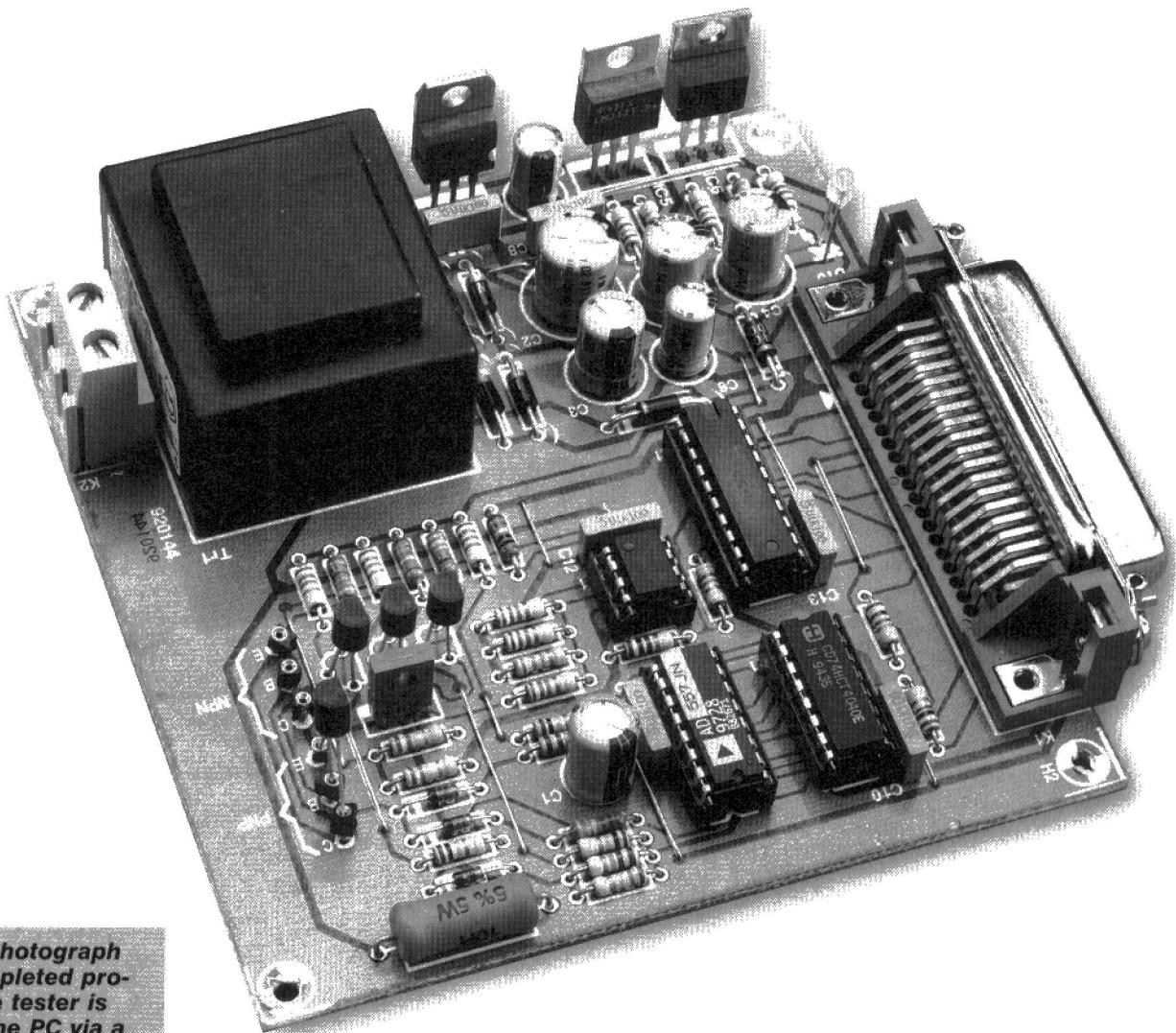
**Figure 4.** The printed-circuit board is designed to house all components, including the mains transformer, but excepting the on/off switch.

#### CONSTRUCTION

Building the tester is straightforward, particularly if it is done on the printed-circuit board shown in Figure 4. The board is compact and designed to house all components except the on/off switch, but including the mains transformer.

Start by laying the wire bridges and fitting socket K<sub>1</sub>. Follow this by fitting first the passive and then the active components. Mind the polarity of the electrolytic capacitors, transistors and integrated circuits.

No special sockets are used for the test terminals, which instead consist of



**Figure 5. Photograph of the completed prototype. The tester is linked to the PC via a standard printer cable.**

coloured banana sockets.

There is no need for the regulators to be mounted on a heat sink.

Since the mains transformer is housed on the board, a space of not less than 5 mm must be allowed when the board is fitted in an enclosure. For security's sake, the underside of the board may be covered with a sheet of PVC or polythene.

#### THE SOFTWARE

The software has been upgraded to a 32-bit version that runs only under Windows 95 or Windows 3.1 with an Win32S extension. Note, however, that the DOS version of the software is still available (see Readers Services section towards the end of this issue).

After the diskette with the program (npnnpn.exe) has been loaded and the printer port selected, check at which address it is located. Then, in the program, select the correct address location: addresses  $378_{\text{HEX}}$ ,  $278_{\text{HEX}}$  and  $3F8_{\text{HEX}}$  can be selected via the menu. A choice then has to be made as to which type of transistor is to be tested,

n-p-n or p-n-p, and the scale value of  $I_{CE}$ : 80 mA, 100 mA, or 120 mA. Note that the scale value affects only the scale of the characteristic, not the settings of the hardware.

For the calibration, state how many settings of base current will be used. This may be as many as eight, that is, no base current or a base current that increases from  $25 \mu\text{A}$  to  $175 \mu\text{A}$  in seven steps. Next, set the number of steps (maximum 256) with which  $U_{CE}$  is to be composed from 0 V to 9 V.

The test results may be stored in CSV (Comma Separated Value) format, which enables them to be processed later on in a spreadsheet. In this way, a database with transistor data may be built up.

[980022]

ELEKTOR		<input type="checkbox"/>
240V ~	50Hz	
No. 980022		
F = 200 mA T		

# Digital Audio Broadcasting (DAB)

## *Part 2: Data management of the DAB signal*

Last month's first instalment of this two-part article dealt with

the way the audio data are transmitted. This second and final part looks at the flexible bit rate management used in the production of DAB signals, the likely design of a DAB receiver, and the spread of DAB in the English-speaking world today and tomorrow.



### **BIT RATE MANAGEMENT AND DATA SERVICES**

The audio programmes and data services carried in a DAB ensemble normally have different requirements as to transmission quality and thus have dissimilar bit rates. A high-quality music programme obviously needs a larger transmission capacity than a simple news channel. But even different data services may have dissimilar requirements. Consequently, individ-

ual service (or programme) providers can transmit their services at completely different data rates.

The Eureka 147 standard makes it possible to reconfigure the DAB multiplex dynamically, that is, during an ongoing programme. This is a useful feature in the case of programmes that include a five-minute newscast on each and every hour. In that time, the data rate may be reduced and the capacity so freed used for other services. Such a reconfiguration may look like that

By our Editorial Staff

shown in Figure 3.

In the DAB system, it is not possible to allocate several frequencies to an individual service provider, since each of these is allocated a relevant data rate in a DAB ensemble. However, data rates in an ensemble may be variable: if, for instance, during a music programme news is broadcast on the hour, the data rate may be briefly reduced from 192 kbit/sec to 96 kbit/sec or even 64 kbit/sec. The capacity so freed can then be used for other services that need only a small capacity, such as the transmission of a software update, or weather information that is transmitted every hour.

Since, technically, the bit rate management is effected in the multiplexer, the additional services may come from different programme providers.

For the transmission of data in addition to, or instead of, audio information, DAB provides in principle three kinds of data service: Programme Associated Data (PAD); radio data services independent of audio information (non-PAD); and complementary services to closed user groups (CA – conditional access).

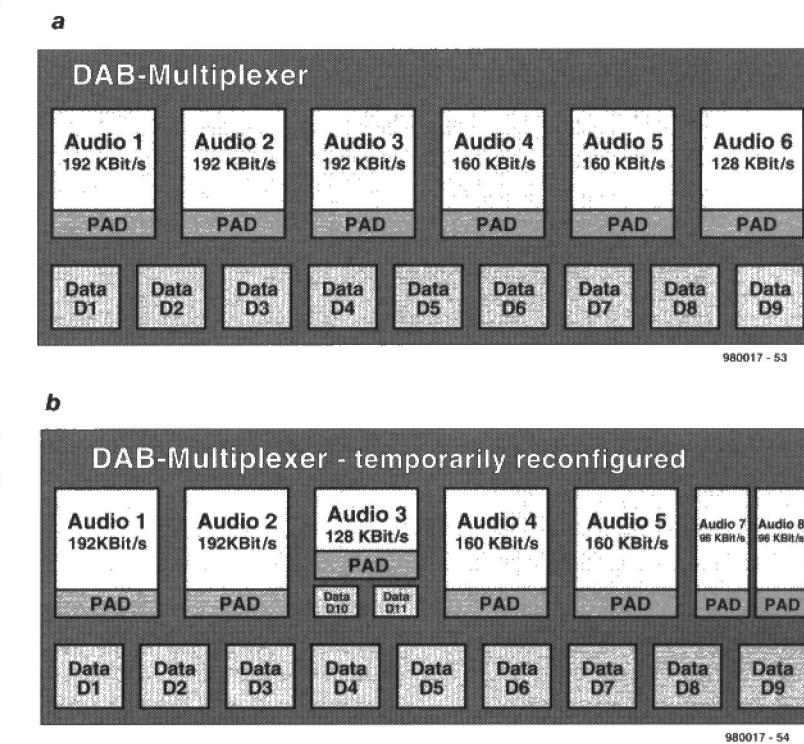
As already mentioned, PAD is embedded in, and transmitted with, the audio data frame. Normally, the data to be included with the programme are conveyed to the programme providers. This may be data for the volume control of a receiver; or data such as in the Radio Data Service (TP\*, TA\*, TDC\*, PTY\*, RT, and so on), but also text and graphics as in teletext information. It is up to the service provider to decide whether the PAD is transmitted at a minimum of 667 bit/sec or a maximum of 64 kbit/sec.

Examples of non-PAD services are electronic newspapers, service information of a local tourist bureau, traffic information direct from the traffic control computer, paging, aircraft flight details, and many more. An interesting one is the transmission of correction data for differential GPS†.

Each and every data service in a DAB ensemble may be used by groups of users or single users with conditional access – relevant encoding and decoding functions are catered for.

The transmission of non-PAD services may be continuous or, in case of small capacity ones, in a submultiplex of a data packet. Three transmission channels are used for this in DAB: a synchronization channel; a Fast Infor-

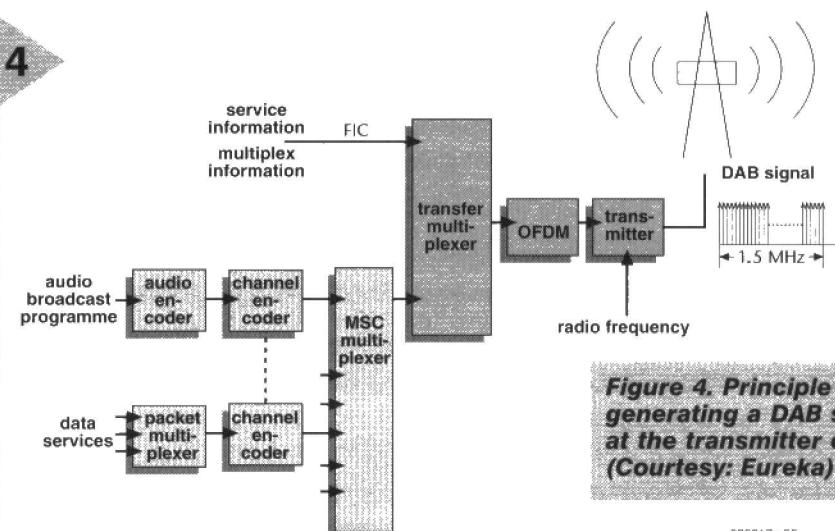
**Figure 3. The intelligent bit rate management of DAB makes possible a flexible reconfiguration of the individual bits during an ongoing transmission.**



mation Channel (FIC); and a Main Service Channel (MSC). Data bits are normally transmitted via the MSC, but sometimes via the FIC. These two channels use dissimilar means to ensure error-free transmission.

The FIC contains all necessary information on the audio and data ser-

vices and their components (MCI – Multiplex Configuration Information), including position in the multiplex, length, error protection, conditional access, and addressing. If the multiplex contains only few components, only few bits are needed for the description of these components. The capacity



**Figure 4. Principle of generating a DAB signal at the transmitter end. (Courtesy: Eureka)**

\* TA = traffic announcement

TP = traffic programme

PTY = programme type

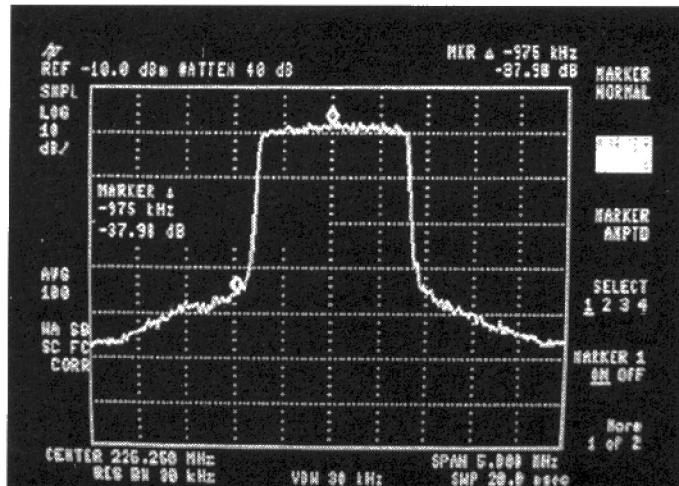
TDC = transparent data channel

RT = radio text

† GPS = Global Positioning System

\*\*CD-quality audio broadcasts will in themselves be insufficient incentive for the majority of listeners to splash out on a DAB receiver.

Moreover, it is a well-established fact that although most of us spend a lot of money on audio hi-fi equipment, this is usually installed in the living room, while most of our listening is done on a simple (often portable) receiver in the kitchen, bathroom or bedroom.



**Figure 5. Frequency spectrum of a DAB transmission in Band III. (Courtesy: Eureka)**

then released is used for data services; this is termed Fast Information Data Channel. The FIDC may be used for paging or alarm systems.

The MSC is divided into subchannels (SC), whose capacity must be a multiple of 8 kbit/sec. An arbitrary part of the MSC may be used for data services.

In the so-called Stream Mode, a subchannel will cater for only one service at a fixed allocated data rate. In certain circumstances, this leads to an uneconomical use of the capacity, but it has the advantage that the receiver can evaluate the data in a straightforward manner.

In the Packet Mode, the data of sev-

eral services are divided into packets of fixed length. Each packet has as address the identification of the service to which it belongs. The capacity of each service may be increased if certain service addresses are transmitted more frequently than others.

#### TODAY ...

Ten years have elapsed from the original concept of Eureka 147 in 1987 to the introduction of the first DAB consumer products (by a number of European as well as Japanese manufacturers) at the International Consumer Electronics Fair in Berlin last year.

Design of suitable chips went hand in hand with the development of the equipment. This design was undertaken by a group of research establishments led by Philips. The chips will be manufactured by Philips, Bosch, Temic and SGS Thomson (at the time of writing: early 1998).

## MUSICAM and MPEG Layer II

The Moving Picture Experts Group (MPEG) has chosen MUSICAM after intensive tests from among 14 competing proposals for normalization by the ISO/IEC (International Standards Organization/International Electrotechnical Commission) as MPEG Audio Layer II.

MPEG Layer II enables the pulse-code modulated (PCM) bit rate required for recording a CD to be reduced by a factor 7, that is, to 192 kbit/sec, without any audible loss of quality.

Although Eureka 147 is a combined European development, great interest in it has come from beyond Europe, culminating in the setting up of the WorldDAB Forum early last year. The forum was set up to take DAB from the development laboratory into the industry and thence to the consumer.

It is hoped by manufacturers and retailers alike that DAB will take off in earnest this year. Unfortunately, the signs for this to happen are none too encouraging. There are two problems: one is the dearth of DAB receivers (since no one really knows what the consumer wants\*\*) – and is prepared to pay); the second is that, in general, the public has not (yet) been converted to DAB.

Nevertheless, the WorldDAB Forum reckons that this year about 100 million people in Europe will be in reach of DAB services: about 40 million in Germany, 25 million in the UK, and 35 million in Sweden, Belgium, Den-

## DAB in the United Kingdom and some Commonwealth countries

**In the United Kingdom**, the Government set the framework for the development of DAB in the 1996 Broadcasting Act. The BBC began an operational DAB service in September 1995 in the London area and is now building up its transmitter network so that 60% of the British population will be covered by the middle of this year. The regulatory body for commercial radio, the Radio Authority, has announced a "fast burn" approach to licensing private radio multiplexes at both national and local level. A number of private stations are already operating a pilot service.

**Australia** looks to be moving ahead towards adopting the Eureka 147 system. In 1996, the Government-appointed Digital Radio Advisory Committee expressed support for Eureka 147 as the appropriate delivery system for Australia. Pilot services are operating in three major Australian cities. Tests have also been carried out of satellite-delivered DAB.

**Canada** has remained at the forefront of Eureka 147 developments after commercial radio and CBC announced their

plans for initial DAB services in late 1996. A group of Toronto-based commercial broadcasters have established full-time transmitters on Toronto's CN Tower to carry the programming of 15 radio stations. At the same time, CBC announced some months ago that it would bring DAB to 75% of the population over the next five years.

**India** is looking to the Eureka 147 system as the future of radio there. The public broadcaster, All India Radio, started preliminary studies and experiments and set up a test transmission system in Delhi. Over the past year or so, work has been orientated towards DAB planning, satellite distribution of a DAB ensemble and its relay in major cities.

**In Singapore**, DAB was demonstrated at the Asia Telecom 97 by the Singapore Broadcasting Authority in association with Deutsche Telecom. Further trials, using both L-band and VHF, took place last year.

**In South Africa**, a seminar in late 1996 on DAB organized by the South African Broadcasting Corporation and Sentech, the transmission provider, led to the formation of a South African DAB Association. Sentech has set up a test facility in Johannesburg to serve as a pilot and development system.

mark, the Netherlands, Hungary and Switzerland. Other countries intending to introduce DAB in the very near future are Italy, France, Finland, Switzerland, and Poland.

Outside Europe, Canada is the fastest mover to construct a DAB network. It is hoped that 75 per cent of the population will be in reach of DAB services within five years. Other countries that have made extensive preparations for the introduction of DAB are China, India, Singapore, South Africa, and South Korea.

In Japan, the industry is interested in DAB, but only as far as production for export markets is concerned. The NHK, Japan's national telecoms authority, prefers the VHF In-Band Digital Radio.

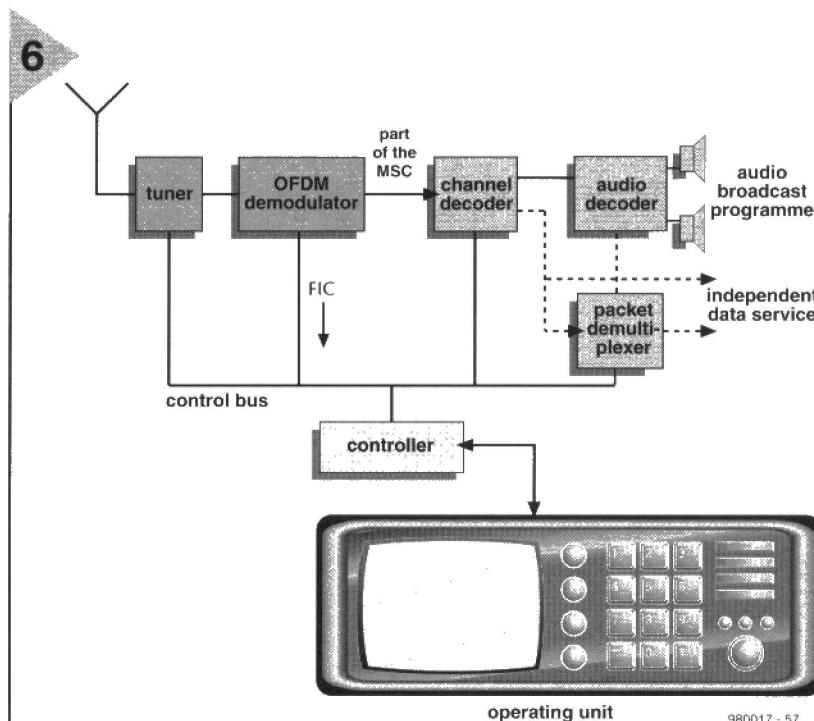
In the USA, the National Association of Broadcasters (NAB) opposes the introduction of DAB and has come out in favour of In-Band Digital Radio for operation in the VHF and medium-wave bands. The first licences for satellite-controlled In-Band Digital Radio have already been awarded.

### ... AND TOMORROW?

Although the Eureka 147 specification is for terrestrial networks (T-DAB), consideration has been given to the possibility of satellite-supported transmissions (S-DAB) to cater for supranational coverage and also to enable national coverage in large countries such as India and China.

The European Space Agency (ESA) has already proposed a DAB satellite in their Archimedes programme. An unusual feature will be the use of satellites in a highly elliptical orbit (HEO) —see Figure 8. The reason for this is that the elevation in northern Europe of geostationary satellites circling above the equator is only about 30°. The likely masking by mountains, tall buildings and forests would seriously degrade the reception of DAB transmissions in mobile units. An HEO ensures that the satellite is more or less at right angles to its target area at its apogee (orbital point farthest away from the earth). This would preclude any masking of the transmission.

The paths of a satellite in an 8-hour orbit (M-HEO) are 120° of longitude



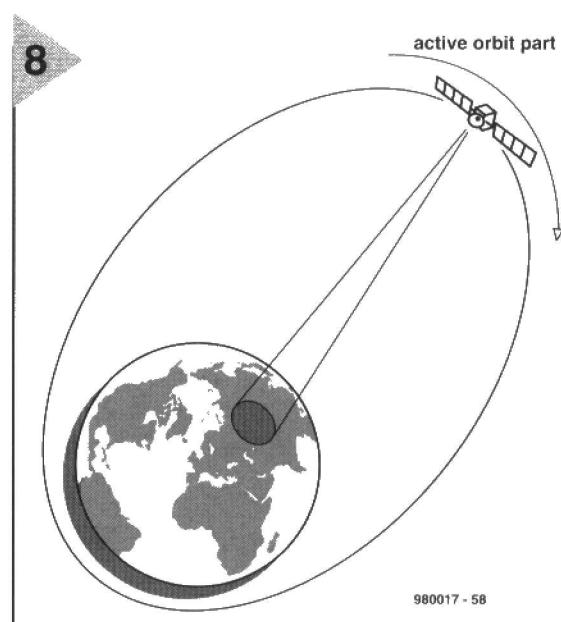
980017 - 57

**Figure 6.** A DAB receiver is likely to consist of a tuner, loudspeaker, graphic screen, processor, and large memory (and a user-friendly interface to operate it). (Courtesy: Eureka)

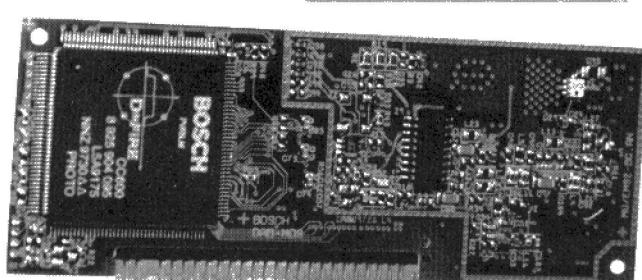
away from the equator, so that the satellite can serve, say, Asia, Europe and North America. This requires several satellites in time-spaced identical orbits, since the transmission of a single satellite can be received for only the few hours it is at its apogee. Apart from the satellite's large elevation (>50°), the relatively shorter distance between it and the receiver results in a lower transmitter power being needed.

The first phase of the Archimedes proposal foresees three satellites transmitting at 1.5 GHz. Each of the three transmissions will be a circular spot-beam with a diameter of about 2000 km, so that the three would cover West and Central Europe, South West Europe, and South East Europe, and also provide a pan-European footprint.

[980017]



**Figure 8.** The European Space Agency (ESA) has already proposed a DAB satellite in a Highly Elliptical Orbit (HEO) for coverage of large territories.



**ELEKTRONIK**  
**ELECTRONICS**

# EXTRA

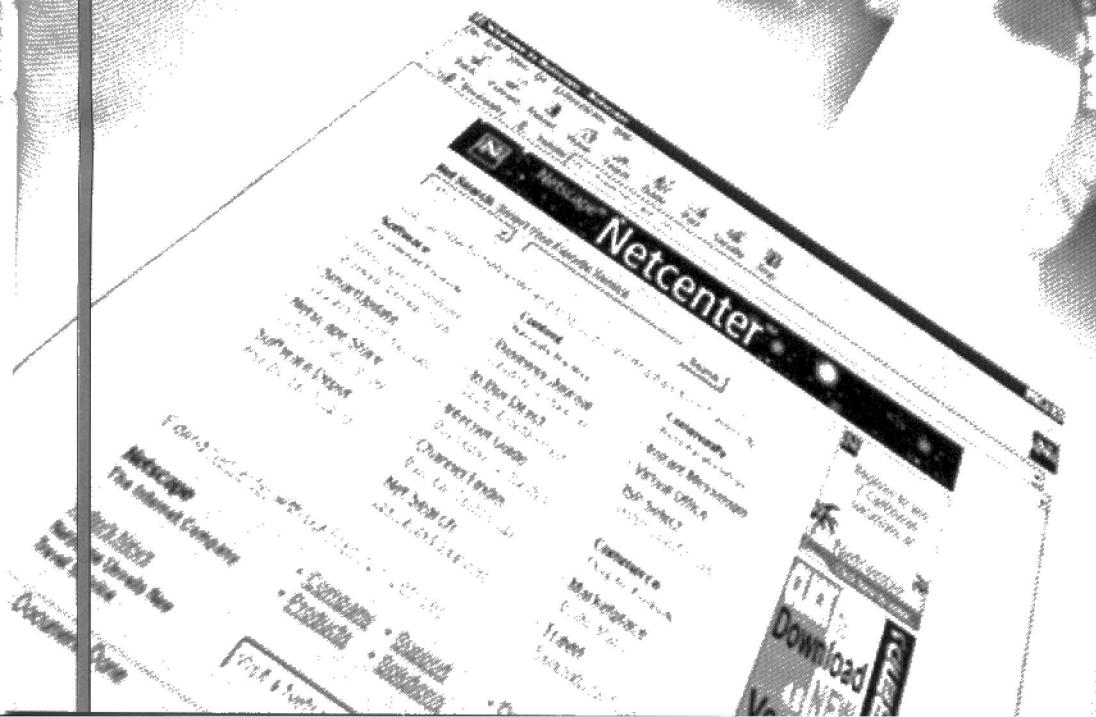
# PC TOPICS

**2**  
**faster access to  
the Internet**  
by cable and satellite

**8**  
**mains filter with  
overvoltage  
protection**

increases the noise immunity of sensitive circuits

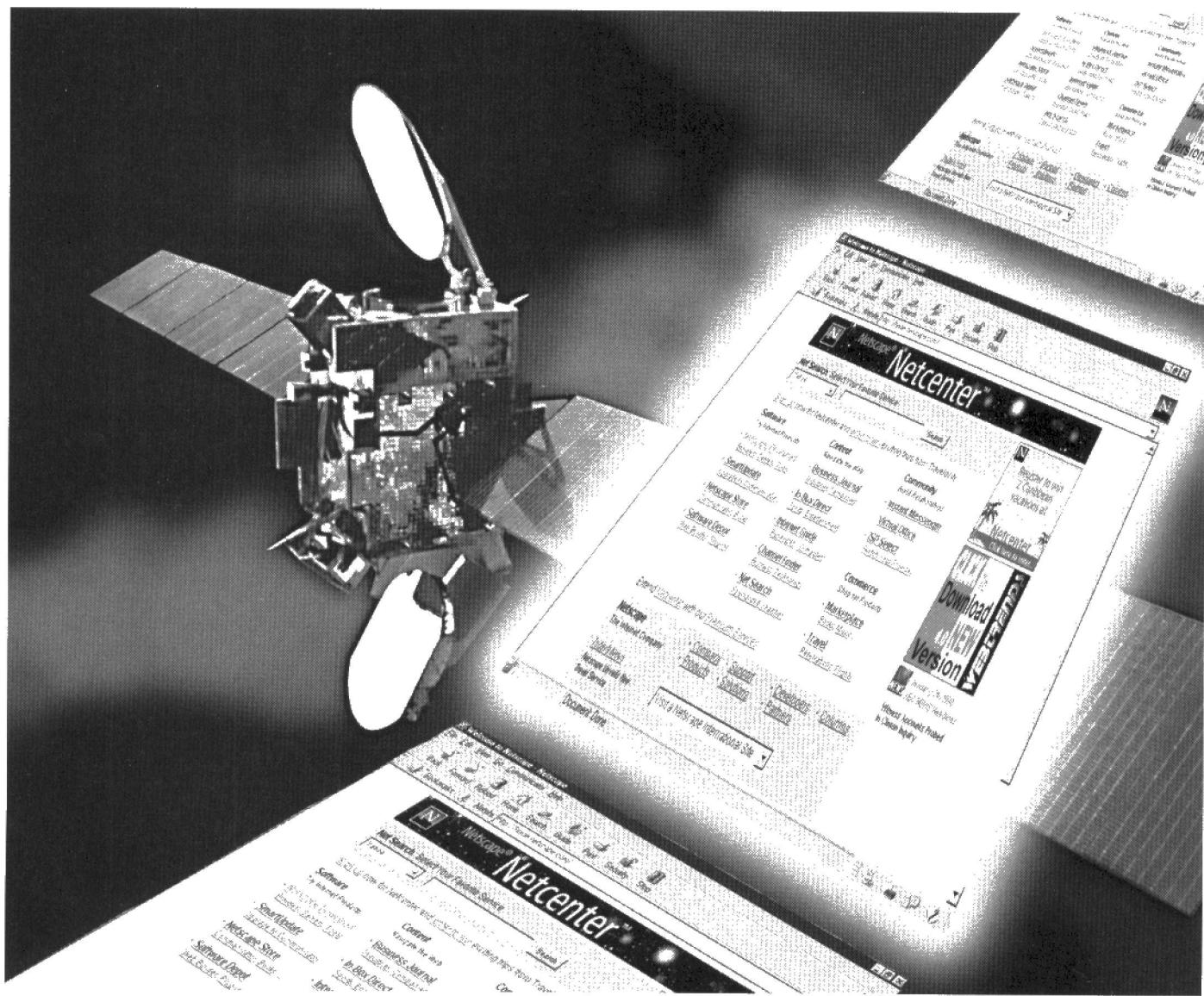
**12**  
**the modern  
printer port**  
IEEE 1284 is  
quickly gaining ground



Many of you will recall the days when a new, and then very fast, modem meant euphoria. "From now on, communication with the Internet will be faster, better, etc." is what many computers owners must have thought at that time. Alas, speed is a relative notion in computer land. Meanwhile, new communication technologies have been designed to speed up Internet access. This article provides a glimpse of what the future has in store for Internet users.

# Faster access to the Internet

**by cable and satellite**



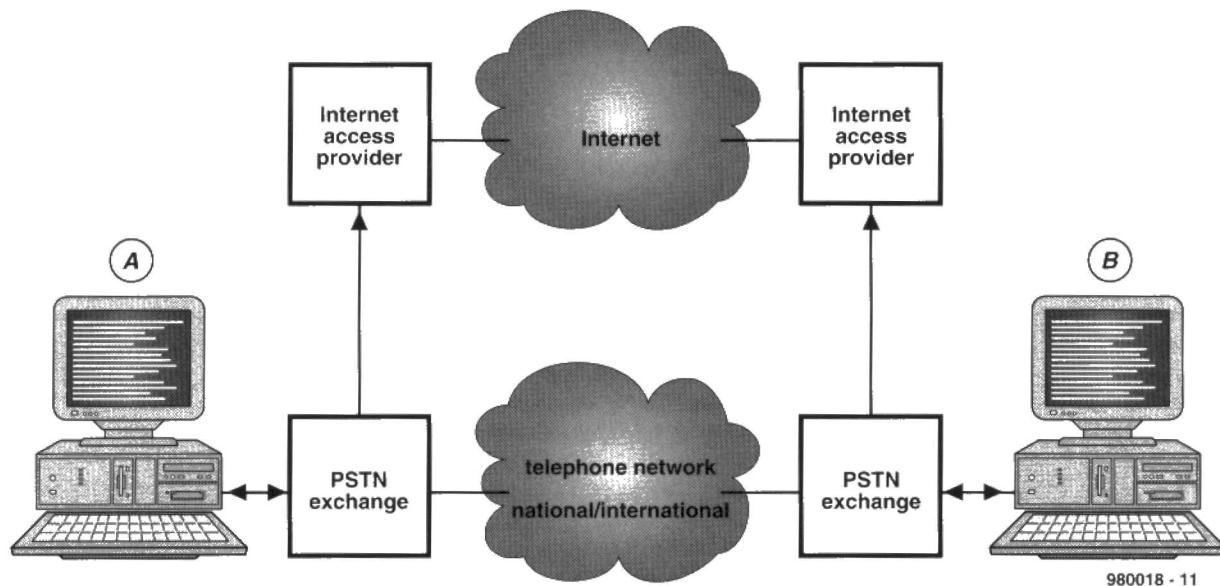


Figure 1. Traditionally, part of an Internet link is by way of the plain old telephone system (POTS).

Internet connections make ever-heavier demands on the bandwidth of a communication channel. Because of the increased information density (these days nearly all web pages have graphic elements, and they support sound and exhibit photographs), a pretty fast data line has to be available to enable the web pages to be built at reasonable speed. Moreover, work on new, 'heavier' services like distributing digital video via the Internet is underway. Consequently, a 14k4 modem is just too slow to surf the Internet, while a 33k6 modem gives reasonable results, and an ISDN connection using a bandwidth of 64 kbit/s is a good alternative these days (though overpriced in the UK). ISDN even allows you to aggregate two channels, enabling a bandwidth of 128 kbit/s to be achieved. Looking at the current trend in technological developments, you may safely assume that even that kind of speed will not be sufficient some time in the near future. The speed of a modem is, incidentally, only one aspect of the case—the internal capacity (bandwidth) of the Internet and the provider's connection to the Net must not be bottlenecks either. In more cases than you would care to think of, the datastream between provider and end-user is ultimately much slower than the theoretical capacity offered by the modem.

Let's return to the communication between the end-user and the service provider. So far, two systems are in use to realise the communication between the Internet and you, the end-user. The vast majority of individual users will faithfully connect to their ISPs by way of the public switched telephone network

(PSTN), also jokingly referred to as POTS (plain old telephone system). Corporate (business) users may resort to leased datalines, which are much faster. In fact, leased lines may supply a bandwidth that matches the exact requirements of the (corporate) user, so that a perfect, seamless link may be made with the corporate network. This type of connection is far too expensive for individual users, hobbyists and other occasional users, who are more or less forced to opt for a modem-PSTN connection. Typically, the available bandwidth will then depend on the quality of the telephone line and the modem technology used. With analogue connections, that is, connections using a standard telephone dial-up connection, the highest available speed is currently offered by the asymmetrical 56 kbit/s standard.

With the increased demand for fast datalinks and the rapidly growing number of Internet users in mind, new service providers seem to pop up almost every day. The coming years will no doubt bring us a fierce and interesting battle between cable-TV companies, electricity boards, telephone companies and other suppliers of information services. Each of these will attempt to induce individual Internet users to go for their offerings of fast Internet services.

### Telephone at the hub

The drawing in **Figure 1** illustrates how today's Internet connections are built up. The end-user relies on his/her telephone line to dial the Internet Service provider (ISP). In this way, the end-user

causes a digital connection to be established using this (analogue) telephone line. Using a modem bank and a network server, the provider arranges for the actual connection to the Internet to be established. Depending on the final 'destination', a Web site being visited, or an e-mail message to be delivered, a second telephone line is employed at the 'far' side. Actually, the Internet 'bypasses' a piece of the telephone network whenever it allows two end-users to communicate with each other. Ultimately, digital data from one computer is delivered, unmodified, to another, which may be at the other side of the globe! Once you get this point, it is easily understood why telephone companies are striving to find a solution that enables end-users to be connected directly to the Internet. The telephone exchange then has to create the link with the Internet. In a number of cases, the service provider is then no longer required. This option is currently under investigation, and there are already encouraging signs from a manufacturer claiming to have found the solution.

Internet providers, afraid of being abandoned by their millions of users, will of course try to counter this development by offering services that reduce the role of the traditional telephone companies.

In this context, it is interesting to see that the European Commission recently decided that Internet 'phone links need not be subject to special regulations. This decision may be revised, however, when we enter the year 2000 and the EEC will look into the problems again. Until that time, Internet providers are in

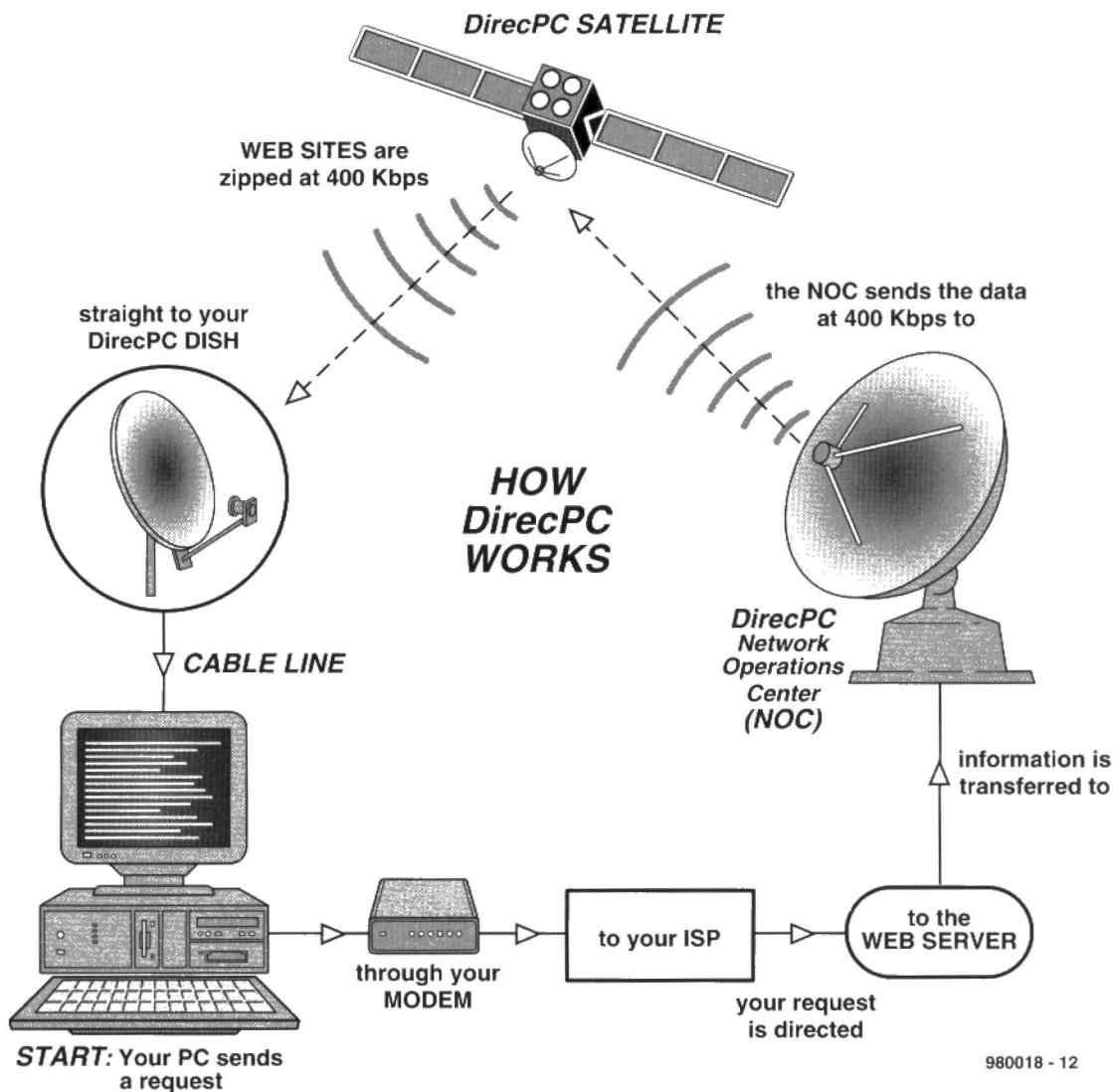


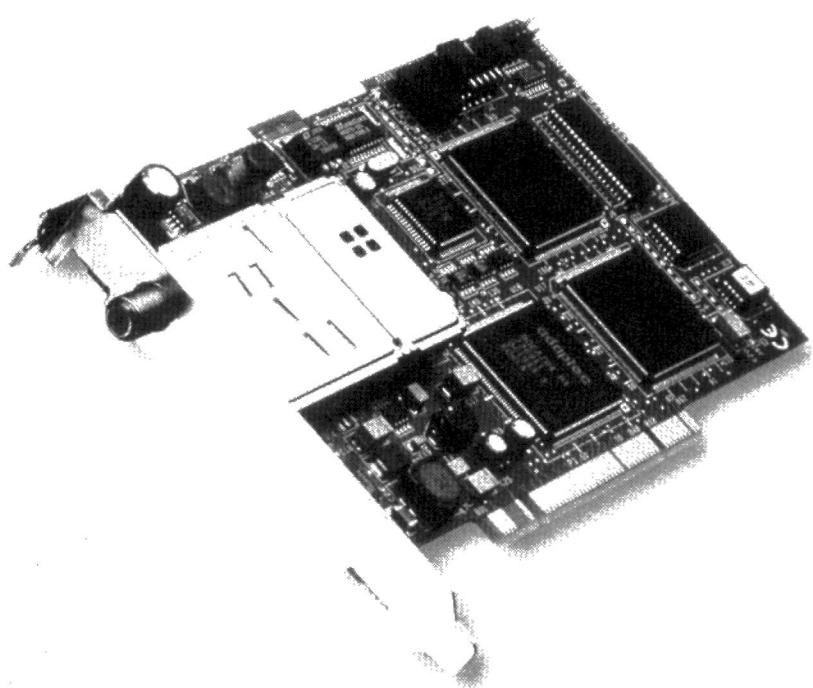
Figure 2. Using DirecPC the end-user employs a modem and a telephone line to dial into the server of his ISP, sending a request for information. The requested information is returned over the air by means of a fast satellite link.

a position to offer national and international telephone services to their customers. True, these services have their limitations. What counts, however, is that they are always cheaper than any overseas call. Consequently, telephone companies have rushed to promote the development of this new Internet application.

The EEC reached this decision because the prevailing opinion is that Internet telephony is not a separate service aimed at making a profit, but rather an extension of Internet services already available to the public.

### Analogue modems

A number of modem types are currently available for connecting to a regular telephone line. The theoretical speeds achieved by these modems range from 14k4, 28k8 and 33k6, up to 56k. The first three rely on symmetrical



connections with the same speeds being available for the upstream and downstream data. The latter modem type, generally referred to as '56k', employs an asymmetrical connection. Moreover, because of its special technology, a 56k modem may only be used if the Internet provider supports the relevant protocol, and a suitable telephone line is available.

It is generally assumed that 56k modems are pushing the limits of what can be achieved in terms of bandwidth on ordinary (copper) telephone lines. No doubt, new technologies will be developed that allow service providers to offer higher bandwidth and thus more speed to their customers.

## ISDN, a fast alternative

In the UK, ISDN is currently the fastest and affordable way available to small business users to jump the Internet bandwagon, and be assured of reasonable speed. Unfortunately, British Telecom, unlike some of its Continental counterparts like Deutsche Telekom and PTT Netherlands, for some reason maintains ISDN price levels which are ludicrous, and way beyond the reach of private individuals.

A standard ISDN connection (BRI, Basic Rate Interface) offers two channels (B channels) of 64 kbytes/s each, which

may be aggregated (bundled) to give a single channel with a capacity of 128 kbytes/s. Doing so (in theory) creates a bandwidth that is four times larger than can be achieved with a 33k6 modem.

A third channel (D channel) with a bandwidth of 16 kbytes/s is reserved for special control and signalling functions within ISDN. Although there are a few telephone companies that put this extra bandwidth at the user's disposal for a permanent link to the Internet, the bandwidth is generally of no use to customers. Although this channel offers only a small bandwidth, it is perfect for transmitting information with modest speed requirements. For example, email messaging and Stock Exchange data. While you make a telephone call, data is automatically retrieved from the Internet.

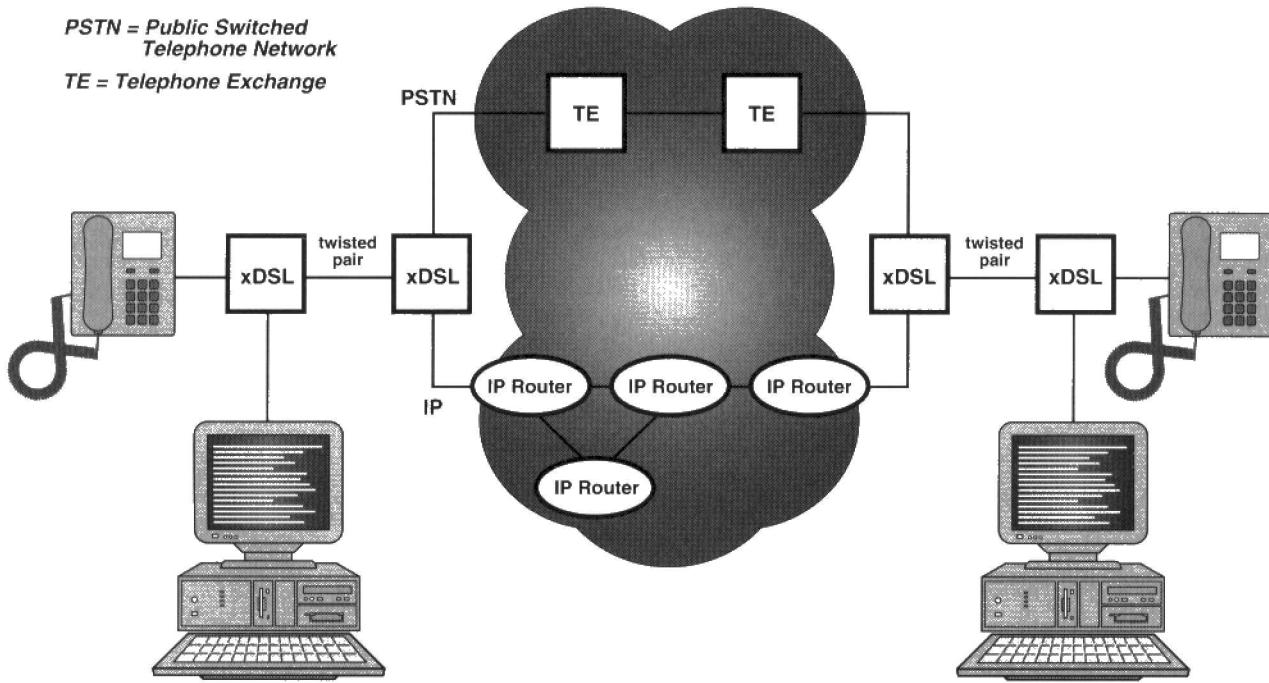
However, a real breakthrough with a promise of much higher data rates calls for a totally different approach. It is therefore not surprising to note the arrival of service providers that are not telephone companies at all. These newcomers look poised to modify their own infrastructures in such a way that it is capable of carrying high-speed data traffic.

## By cable tv network

A growing number of cable-tv network operators are beginning to realise that

existing infrastructures can handle a lot more than just two dozen or so TV programmes. Using a cable modem and a hefty investment in the layout of existing cable networks and their infrastructures, it should be possible, in principle, to realise two-way high-speed data communication. As far as speed is concerned, the cable modem (if available privately) is then likely to become the fastest link to the Internet. Because the standard behind these modems has not yet been finalised, it is not yet possible to give exact figures as regards the speeds achieved by this new technology. An educated guess, however, is 2 to 10 million bits per seconds, which is far more than the 128 kbytes/s and 33.6 kbytes/s (theoretical) maximum rates offered by ISDN and plain telephone lines respectively.

When talking about cable modems, a distinction is made between symmetrical and asymmetrical connections. An asymmetrical link means that the path between the user and the service provider is slower than the path in the opposite direction. This situation may be compared to that of the 56k modem. None the less, the speed of this 'slow' upstream channel is still 500 kbytes/s, which is impressive when compared with what is normally feasible using the standard telephone network.



980018 - 13

Figure 3. With xDSL modem techniques (i.e., ADSL and VDSL), high-speed data is sent down twisted-pair copper cables, along with ordinary telephone traffic (PSTN or ISDN). At the local telephone exchange, the data traffic is sent to an IP router. Next, the traffic is arranged via the Internet.

Internet service providers also use proxy servers to make access to popular web sites as fast as possible. A proxy server holds instantly available copies of these sites. Being 'closer' to the end-user, popular web pages can be loaded much faster from a proxy server than from the server operated by the original site builders. A dedicated proxy server prevents users from going under in the very busy traffic on the Internet proper.

Cable modems are equipped with an Ethernet connection, and are incorporated in a small network using a PC-hosted Ethernet interface. The main advantage of this set-up is that the modem connection with the Internet is always available, which means that no time is lost on dialling in and logging on. Moreover, the 'bottleneck' effect of a slow serial port is eradicated. Because the PC communicates with the cable modem by means of the TCP/IP protocol, special software is not required.

To the computer user, the application of an Ethernet interface means that data may always be found rapidly, but also that he/she has to pay attention to files that have been marked as 'shared'. If these files can be accessed without a password, other Internet users may get at them.

As we write this article, the use of cable modems is limited to a couple of experiments only. Clearly, it will take some time for cable companies to get used to the idea of seeing their infrastructure carry two-way data traffic. Consequently, all cable distribution amplifiers have to be adapted, and large parts of the network have to be replaced by fibre optic cables. Once this has been done, the cable modem is probably the fastest way to cruise the Internet. However, cable penetration being modest in the UK as compared with, say, Germany and The Netherlands, the cable modem may be a non-starter in this country.

## By satellite

The advantage of a wireless data link, for example, by satellite, is that additional infrastructure is (in principle) not required. In the USA and Germany, it is currently possible to use a satellite dish to receive information from the Internet. This new, wireless, link guarantees fast traffic even under adverse conditions. The first service provider to make Internet access by satellite a reality is a US company called DirecPC, a subsidiary of DirecTV. The company specialises in television services by satellite.

The highest data speed that may be achieved using a satellite dish is about 400 kbit/s, which is more than three times as fast as an ISDN connection. The new technology has a snag, however. The dish only allows the reception of data (downstream) — upstream data is still sent by ordinary telephone lines. So, there's still a telephone bill to pay in addition to the monthly charges raised by the Internet service provider. In case the user needs to obtain information via the Internet, he/she has to dial into the ISP's server (by telephone) and send the relevant request. The ISP has a fast link to the Internet, and will respond to the call by uploading the relevant data to the satellite. The satellite, in turn, arranges the transmission of the requested data to the user's dish. This rather cumbersome approach, which causes an enormous detour for the data, is of particular interest whenever large amounts of data are needed. None the less, when compared with competitive systems, Internet by satellite supplies only average results at pretty high cost. This makes the system a non-starter for private users, at least, for the time being.

## ADSL: phone lines go digital

As communication lines used for the telephone network become more powerful, it seems that there is an increasing danger of the link between the user and the local telephone becoming a bottleneck. In practice, the 2-wire twisted-pair copper cable that brings the telephone network to your home is not very long, and it lends itself to creating faster links provided new modem technologies are employed.

ADSL (asymmetric digital subscriber line) is a new digital network technology capable of employing copper wire pairs as used in the telephone network. On average, a bandwidth of 1.5 Mbit/s is available if you download data over an ADSL line. The uploading speed is 64 Kbit/s. This asymmetric structure lends itself very well to Internet use because the typical user will send far less data to the server than he/she receives from the server. This digital bandwidth is available besides a regular telephone service, and is suitable for combining with ADSL in the near future.

The new ADSL system is in popular use in a number of areas. In Canada, more than 30% of the telephone companies support this protocol. In other countries, ADSL is the subject of extensive experiments.

## Still faster

Although ADSL allows an Internet connection to be established that is pretty fast by today's standards, VHDSL (very high-speed digital subscriber line) makes it possible to convey datastreams of about 10 Mbit/s over twisted-pair copper wires. A disadvantage of this protocol is, however, that the largest distance that may be covered using copper wires is even shorter than the 3 to 5 km achieved by ADSL. However, the distance that may be covered using fibre optics and VHDSL is, in principle, infinite. Considering the innovations currently implemented in the many parts of the telephone network, the fibre optic cable is rapidly approaching your doorstep. In other words, those copper wires are getting shorter all the time.

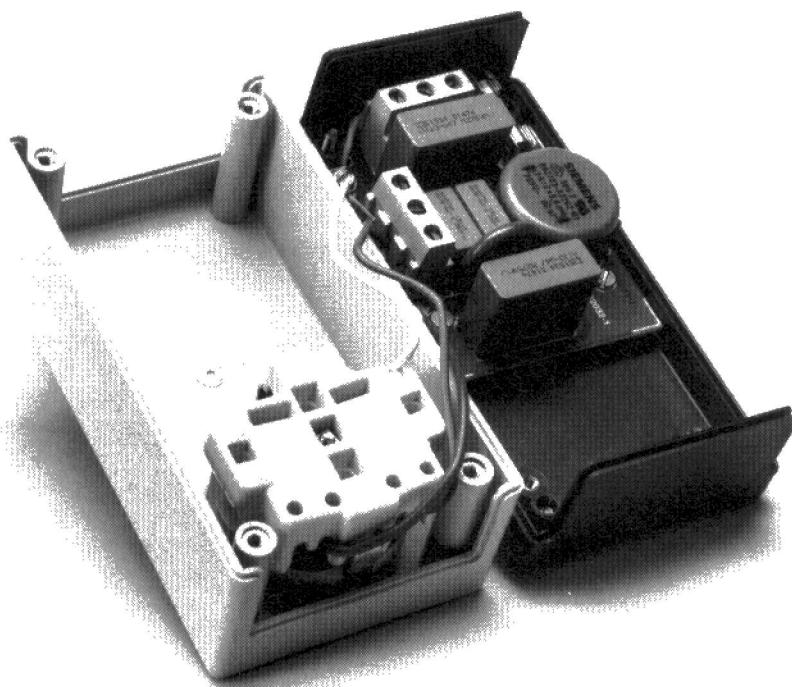
Obviously, the coming years will deliver many changes in fast digital connections to our doorstep. As a result, there are fantastic opportunities for advanced digital services like per-person view and video on demand.

[980018]

This filter fulfils three functions: it acts as a in-phase filter for common-mode noise and as an antiphase filter for differential-mode noise, and it also protects the connected circuit against overvoltages and transients on the mains lines.

Design by H. Bonekamp

# Mains filter with overvoltage protection increases the noise immunity of sensitive circuits



In the last few years, electromagnetic compatibility (EMC) has become an important consideration in the design of electronic circuits. The designer has an obligation to achieve a low level of emissions and a high degree of immunity to external noise, not only for circuits that specifically work at high frequencies but also for most computer, microcontroller and audio circuits. In order to meet this objective at an appropriate cost, passive and active EMC measures must be taken in all stages of the development process. In principle, one can say that the later that such measures are introduced in the course of development, the more difficult and expensive they are to implement.

Designing a circuit with no regard to its EMC behaviour, and then making it compliant by packaging it in a metal enclosure with a mains filter, will in most cases turn out to be an (expensively) mistaken approach. Adding a mains filter to a circuit which has proven to be overly susceptible to external noise, in spite of the use of all other countermeasures, can only be regarded as a desperate solution. Mains filters are thus required even for DIY projects, prototypes and laboratory models. With commercial mains filters, the designer's usual problem is first to select a suitable filter from the profusion of types available, and then to employ it in a manner which more or less meets the conditions stated on

the manufacturer's datasheet. It is thus quite reasonable to present a design for a universally usable mains filter whose parameters and operating principles are at least fairly well known.

## In-phase operation

You can find a good theoretical introduction to the subject of mains noise in the article "Mains-noise suppression" in the June 1997 issue of *Elektor Electronics*. In the present article, we concentrate on common-mode and differential-mode noise. The difference between these can be explained with reference to **Figure 1**.

If the noise current flows from the source of the disturbance through both mains leads L (live) and N (neutral) to the noise 'recipient', and then returns via the protective earth lead, PE, and the earth, this is called *common-mode* or '*asymmetrical*' noise. If on the other hand the noise current flows through one mains lead to the noise recipient and then returns via the other mains lead (but not via the earth), this is called *differential-mode* or '*symmetrical*' noise. As a rule, most differential-mode noise lies under 500 kHz and most common-mode noise above 500 kHz.

## Technical data

Voltage:	230 V-
Maximum current:	2 A
Common-mode noise suppression: (-3dB at 18 KHz):	50 dB
Differential-mode noise suppression: (-3dB at 35 KHz):	50 dB

The mains filter consists of nine carefully chosen components. The most noteworthy is the *current-balanced choke*  $L$ , which has two identical windings wound in the same direction on a toroidal core. The effect of this choke is different for common-mode and differential-mode noise. A current flowing through a winding generates a magnetic flux in the core. With common-mode noise, the noise currents flow through both windings in the same direction, so that the two magnetic fields add to each other. A common-mode noise current thus sees the full inductance of the choke.

The combination of the inductor and the two capacitors  $C_y$  acts as a low-pass filter for common-mode noise. In order to quantify the attenuation characteristics of this filter, we can consider **Figure 2**, which depicts the filter elements for one mains lead together with the parasitic components that are most significant for common-mode currents, namely the parallel capacitance of the choke and the series inductance of the capacitor. This filter

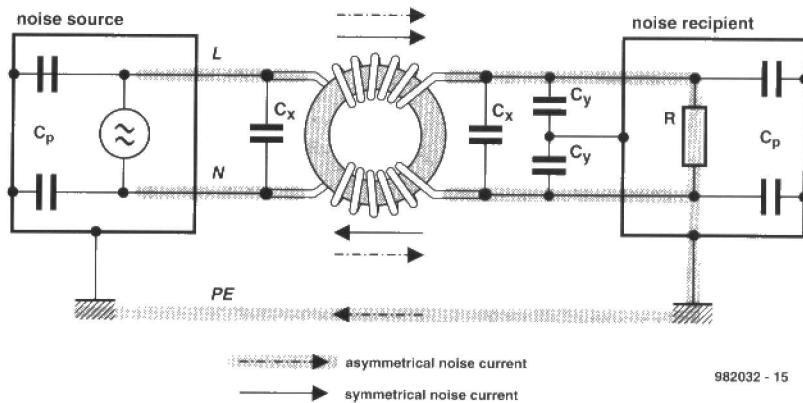


Figure 1. Basic operation of a simple filter between a noise source and a noise recipient. Note the different paths for asymmetric (common-mode) and symmetric (differential-mode) noise currents.

form, are due to two LC networks with resonance frequencies  $f_{CM1} = 1/2\pi\sqrt{LC_p}$  and  $f_{CM2} = 1/2\pi\sqrt{L_pC_y}$ . In order to achieve the maximum possible attenuation, it is preferable to use a toroidal core with a high relative permeability ( $\mu_r$ ) since this results in a current-balanced choke with high inductance. However, non-linear effects

these are Y2-class capacitors with superior mechanical and electrical safety characteristics. Y-class capacitors are constructed such that no mains voltage can reach the safety earth lead under any circumstances (including destructive failure). The Siemens Y-class capacitors used here are only available in values up to 33 nF. Although selecting a set of component values for the common-mode filter may appear to be as difficult as squaring the circle, it has turned out to be quite easy.

The values of the parasitic components depend not only on the construction of the actual components used, but also on the capacitive coupling of the filter with its surroundings and the inductive coupling between the input and output leads. For this reason, (multistage) filters intended to achieve very high attenuation are always housed in well-screened tinned-metal enclosures. Such enclo-

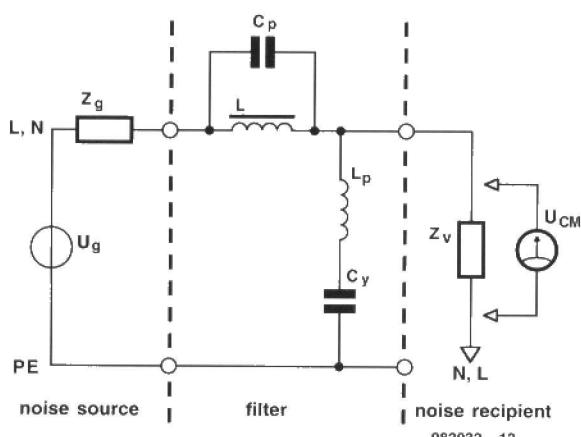


Figure 2. Equivalent circuit for common-mode noise. Only one lead (L or N) is shown.

has an attenuation characteristic with three regions, as shown by the dashed line in **Figure 3**. (Most commercially available mains filters have a similar characteristic.) The low-frequency passband region is dominated by the low-pass LC combination ( $f_{res} = 1/2\pi\sqrt{LC_y}$ ) and has a slope of 12 dB/octave; the effect of the parasitic components is negligible in this region. In the high-frequency region the situation is exactly the opposite: the parasitic components form a 12-dB high-pass filter ( $f_{res} = 1/2\pi\sqrt{L_pC_p}$ ) which allows very-high-frequency common-mode noise to pass with almost no attenuation. The two points of maximum attenuation, between which the attenuation is relatively uni-

due to the saturation of the core are undesirable; in other words, the peak noise currents should not exceed a certain value — although it is precisely these unpredictable noise peaks which the filter is supposed to render harmless. The capacitors can be relatively small, due to the high inductance of the choke windings. This is fortunate, since otherwise the leakage currents through the capacitors to PE could become large enough to trip the earth-leakage current breaker (ELCB). In addition, suitable capacitors that are approved for use in such filters are only available with relatively small values. Specifically, only so-called EMI-suppression capacitors meeting the EN132400 standard can be used;

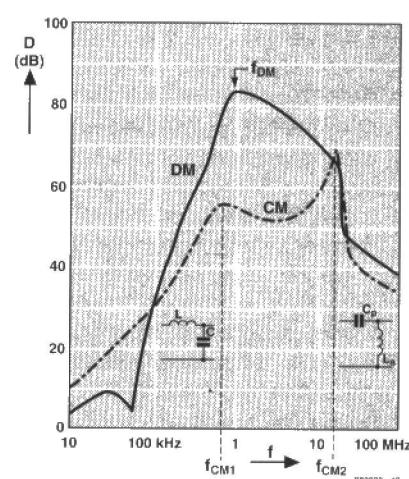


Figure 3. Attenuation characteristics for common-mode noise (dashed line) and differential-mode noise (solid line).

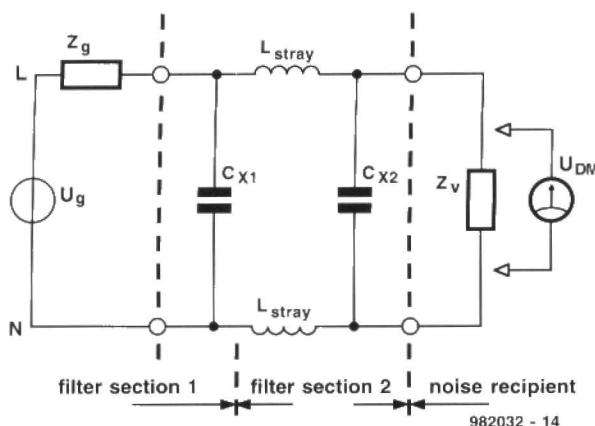


Figure 4. Equivalent circuit for differential-mode noise. The source impedance and input capacitor form the first filter stage.

sures are divided into several isolated compartments for the individual filter sections.

### Antiphase operation

The impedance of the mains network is negligibly small at low frequencies. For higher-frequency differential-mode noise the source impedance can reach values of more than  $100\ \Omega$ , which makes it a significant factor with regard to the mains filter. As shown in **Figure 4**, the combination of the source impedance  $Z_g$  and the capacitor  $C_{x1}$  forms a 6-dB low-pass filter with a relatively high corner frequency ( $f_{-3dB} = 1/2\pi Z_g C_{x1}$ ). For differential-mode noise the current flows in opposite directions through the two windings of the choke, so that the opposing magnetic fields cancel each other out. Differential-mode noise currents thus see only the small stray inductance of the windings ( $L_{stray}$ ), which results from imperfect coupling and amounts to roughly 1% of the nominal inductance. The value of  $C_{x2}$  is chosen to be a factor of 100 times that of  $C_y$  in order to shift the attenuation curve for differential-mode noise to the same frequency range as that for common-

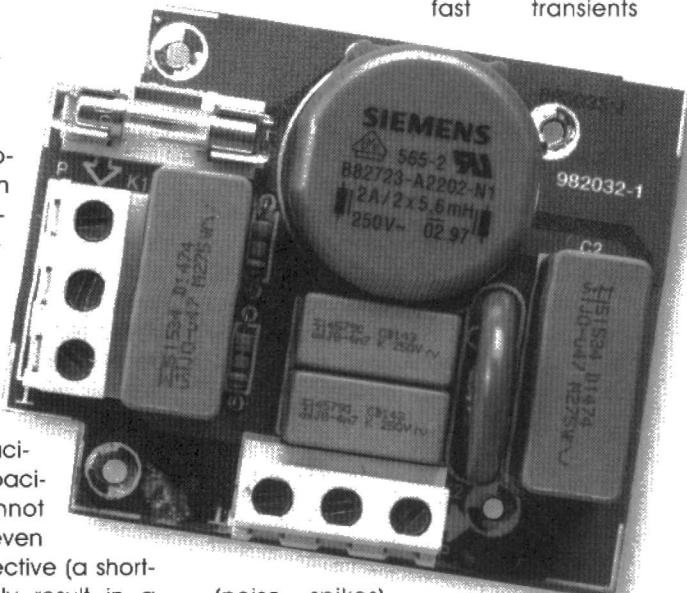
mode noise. EMI-suppression capacitors in the X class (MKT or polyester) meeting the EN132400 standard are available with values up to  $2.2\ \mu F$  in the series which is used here. Significantly smaller demands are placed on X-class capacitors than on Y-class capacitors, since they cannot cause much damage even with when they are defective (a shorted capacitor will simply result in a blown fuse). With this set of component values, the effect of the relatively small  $C_y$  in parallel with  $C_x$  is not significant. The reactive current is of course rather large due to the large value of  $C_x$ , but this does not have much effect on the ELCB.

### Safety measures

The mains filter presented here, whose complete schematic is shown in **Figure 5**, includes certain components which assure additional safety. The first of these is the fuse F1, which limits the current to the allowable nominal value

for the balanced choke (2 A). The two resistors R1 and R2 serve to quickly discharge C1 and C2 when the mains plug is pulled. **Be sure to use two series-connected resistors as indicated**, since a single (470-k $\Omega$ ) resistor is normally not suitable for connection across the mains voltage.

We now come to the last of the three functions of the filter: overvoltage protection. As can be seen from the attenuation characteristics, the filter has practically no effect on high-frequency noise. This also applies to fast transients



(noise spikes) which can have amplitudes of up to several kilovolts and durations of 0.1  $\mu s$  to 1 ms. In order to tame such disturbances it is fully adequate to connect a varistor (a voltage-depen-

## COMPONENTS LIST

### Resistors:

R1,R2 = 220 k $\Omega$   
R3 = 275V SIOV-S20k275  
(Siemens)

### Capacitors:

C1,C2 = 470nF 250VAC class X2,  
Siemens B81133-D1474M000  
C3,C4 = 4nF7 250VAC class Y2,  
Siemens B81121-CB143

### Inductor:

L1 = 2 x 5.6mH/2A 250VAC,  
Siemens B82723-A2202-N1

### Miscellaneous:

F1 = fuse, 2A slow, with PCB mount holder.  
K1,K2 = 3-way PCB terminal block,  
pitch 7.5mm.  
Case: Bopla SE432DE.  
PCB, order code 982032-1, see  
Readers Services page.

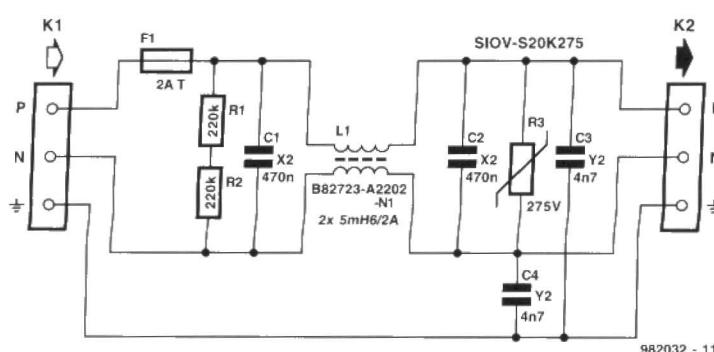


Figure 5. The complete schematic diagram of the mains filter with its nine components.

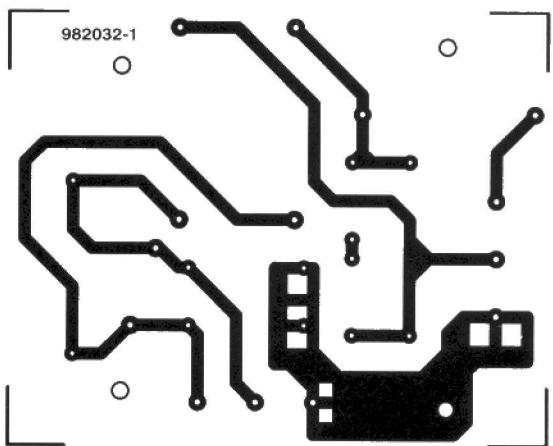
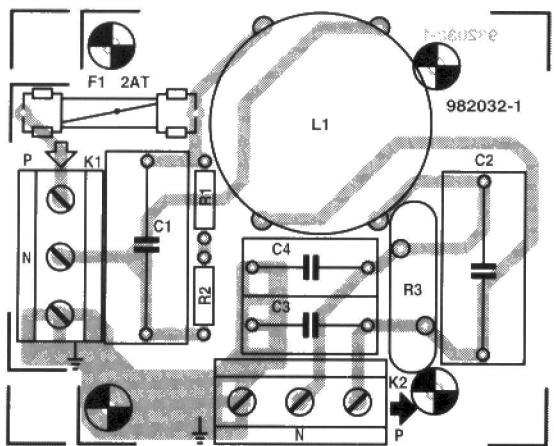


Figure 6. The circuit-board layout guarantees a safe construction in a mains-plug enclosure.

dent resistor) across the mains lines. Such a component has a very high resistance for voltages lower than its rated voltage, and a very low resistance for voltages above this value. Considering the allowed tolerance for

the mains voltage (and for the varistor characteristics) a nominal varistor voltage of 275 volts appears to be appropriate. For the varistor to do its job properly, a series resistance is necessary to 'absorb' the excess voltage. The source impedance of the mains network, which rises with increasing frequency, comes into play here. In the frequency range in question (10 MHz and above), the source resistance  $Z_g$  is greater than  $150 \Omega$ , which is more than enough for proper operation of the varistor.

## Construction and use

We have developed a circuit board for the mains filter (**Figure 6**) with a layout which meets all applicable safety regulations. Mounting the individual components is no problem, but the following must again be emphasised:

**Use only the components which are specified in the components list. Only these components (as opposed to 'standard' types) meet the rather strict safety requirements for this project!**

The circuit board for the filter should be built into a enclosure with a mains plug and socket in such a way that the plug and socket do not sit directly across from each other. The mounting holes of

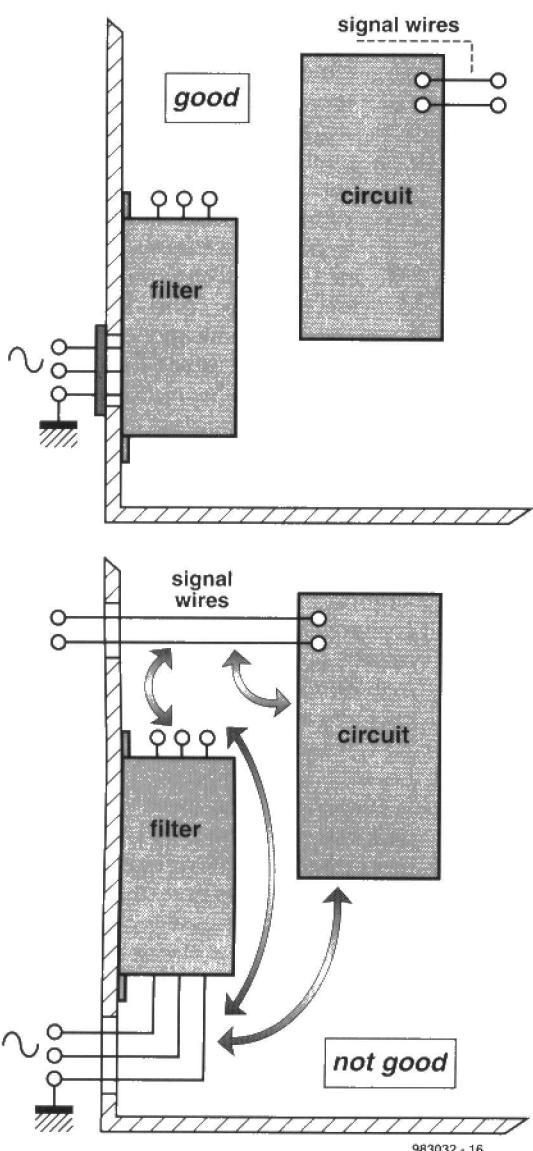


Figure 7. Good and bad ways of mounting of a fully screened mains filter in an equipment enclosure.

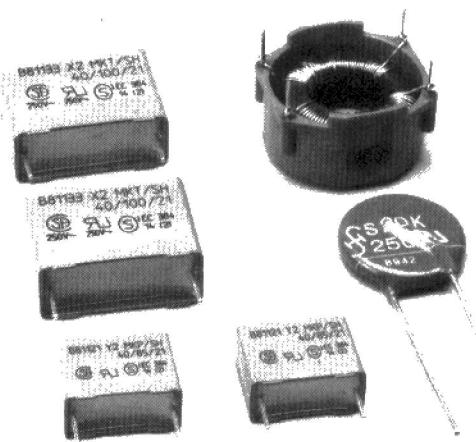


Figure 8. Only these special components may be used in the construction of the mains filter!

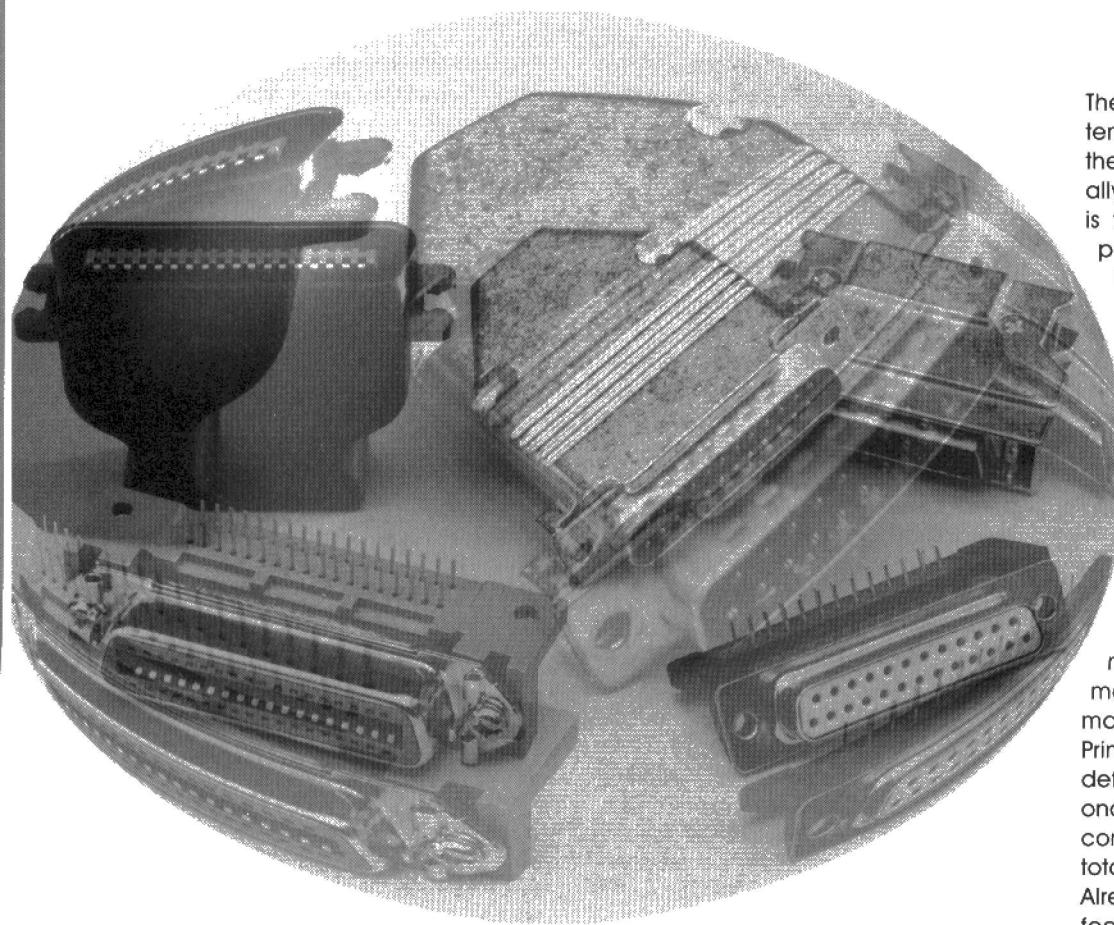
the circuit board do not allow this with the specified enclosure. In order to keep the crosstalk between the input and output as small as possible and meet the specified attenuation values, the input and output leads should be kept well away from each other. The attenuation factors of commercial mains filters cannot be achieved with a plastic enclosure. One should therefore consider using a tinned-metal enclosure if the filter is to be permanently integrated into a piece of equipment. The manner in which the filter is mounted is then critical. Refer to **Figure 7**, which shows what can go wrong and how to do it right.

[982032]

Every modern computer has an advanced IEEE 1284 parallel port. Thanks to this interface, the printer port can be used for more than just driving a printer. In some respects, the performance of this interface comes close to that of an 8-bit SCSI interface.

# The modern printer port

## IEEE 1284 is quickly gaining ground



The standards for the modern bi-directional printer port are laid down in the document "IEEE Std. 1284-1994, Standard Signalling Method for a Bi-directional Parallel Peripheral Interface for Personal Computers". This standard is a conceptual description of a very fast bi-directional parallel connection which with regard to data communication is 50 to 100 times faster than the original parallel port. Yet the new port is still compatible with the older parallel port and the printers which can be connected to it. Before looking at the principles of IEEE 1284, it's a good idea to re-examine the standard parallel interface.

### IBM chooses

When IBM introduced the PC in 1981, they opted for a fast 8-bit parallel interface for driving the printer. This approach was preferred to a serial interface (RS232), which was very popular at that time.

At the time of the PC's introduction the printer was the most important 'client' for the parallel port. In the meantime there have been many technological developments, and the parallel port is now used to connect the PC to scanners, CD-ROM players, portable disk drives, tape streamers and other PCs, as well as to printers.

The problems which have faced system designers in the development of these new applications can be generally attributed to three factors. The first is that the performance level of the parallel port has been stuck at roughly 150 kbytes per second, while PCs have become increasingly powerful. The second is that there is no standard for the electrical interface, which results in compatibility problems between various platforms. Finally, due to the lack of standards the maximum practical cable length is limited to about 1.5 metre.

In 1991, printer manufacturers got together and started discussing a new standard. These manufacturers, which included Lexmark, IBM, Texas Instruments and many others, created the Network Printing Alliance (NPA). The NPA in turn defined a number of features which, once they were implemented in the computer and the printer, would allow total control over the printer.

Already during the definition of these features it became clear that this objective could only be realized if a high-performance parallel port was built into the PC. The standard parallel port could not be used for this purpose.

In response to an invitation from the IEEE, the NPA ultimately developed a new standard for a high-speed bi-directional printer port. The preconditions were that the new port must be hardware- and software-compatible with the existing port and that it must be able to achieve a data transfer rate of at least 1 Mbyte/s in each direction. The working group was assigned the name "IEEE 1284" and the resulting standard, IEEE 1284, was established in March of 1994.

## The parallel port

The parallel port of a PC utilizes 17 signal lines and 8 earth lines. The signal lines are divided into four control signals, five status signals and eight data signals.

In the basic concept, the control lines serve for driving the printer and providing the 'handshaking'. The status lines also play a role in the handshaking, and in addition they provide the 'Busy' signal and indicate error conditions in the interface or peripheral device. Finally, the data lines are used to transfer data from the PC to the printer. Some time after its introduction, the port was slightly improved to allow bi-directional data transfers.

The first column of Table 1 lists the signals which are used with the Standard Parallel Port (SPP). The port itself receives an address in the PC's I/O space, where it utilizes three locations. The base addresses of these ports, which are often referred to as LPT addresses, are  $3BC_H$ ,  $378_H$  and  $278_H$  respectively. Newer implementations of the parallel port, which support the advanced-mode features of the IEEE 1284 standard, use 8 to 16 locations starting at I/O address  $378_H$  or  $278_H$ . The addresses may also be adaptable, as for example with a 'Plug and Play'-compatible parallel adapter card.

## IEEE 1284: the approach

Several different communication modes are defined in the IEEE 1284 standard. For example, the Compatible and Nibble modes can be realized with any existing parallel port. They allow data to be exchanged in two directions. The Compatibility and Byte modes allow a bi-directional data channel to be opened, but a prerequisite is that the ports used must support the Byte mode. In practice this means that it must be possible to read a data byte from the external data lines. This is usually implemented by incorporating a direction bit in the control register. Ports which provide this support are commonly called 'bi-directional' parallel ports. The EPP and ECP modes support two-way communications, since this is part of their protocol. However, these modes require that the hardware includes arrangements for automatically generating the handshaking signals which are necessary for high-speed data transmissions.

Finally, it should be noted that with the exception of the Compatibility mode, each mode renames the status lines to

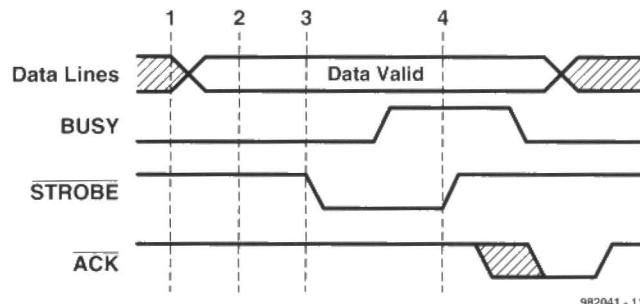


Figure 1. The timing of the standard parallel port (SPP).

Table 1. Signal definitions.

SPP-Signal	Nibble Mode	Byte Mode	EPP Mode	ECP Mode	Pin (DB25)	In/Out
Strobe\	Strobe\	HostClk	Write\	HostClk	1	Out
AutoFeed\	HostBusy	HostBusy	DataStb\	HostAck	14	Out
SelectIn\	1284Active	1284Active	AddrStb\	1284Active	17	Out
Init\	Init\	Init\	Reset\	ReverseRequest\	16	Out
Ack\	PtrClk	PtrClk	Intr\	PeriphClk	10	In
Busy	PtrBusy	PtrBusy	Wait\	PeriphAck	11	In
PE	AckDataReq	AckDataReq	UserDefined	AckReverse\	12	In
Select	Xflag	Xflag	UserDefined	Xflag	13	In
Error\	DataAvail\	DataAvail\	UserDefined	PeriphRequest\	15	In
Data[8:1]	NotUsed	Data[8:1]	AD[8:1]	Data[8:1]	2-9	

\ = actief laag niveau

correspond to the functions which they have within that mode.

### Five modes

If we look more closely at the IEEE 1284 standard, we see that there are five modes which are defined in the standard. Each of these has its own communications possibilities. For communication from the PC to the printer the

Compatibility mode is available, and communication from the outside world toward the computer is possible with the Nibble mode (4-bit data, compatible with Hewlett-Packard Bi-tronics) and the Byte mode (8-bit data). Two-way traffic is possible with the EPP and ECP modes.

The EPP (Enhanced Parallel Port) mode is intended to be used in combination with devices other than printers, such

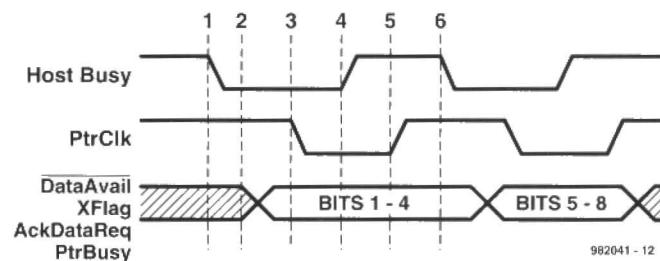


Figure 2. Nibble-mode data transfers. Two cycles are necessary to send a single 8-bit byte.

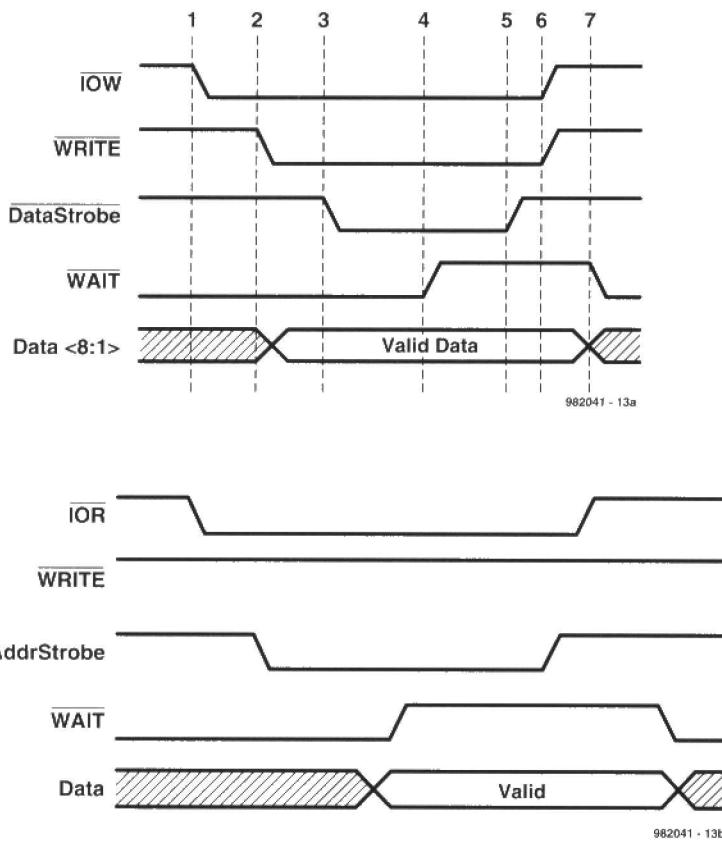


Figure 3. Timing of Data\_Write and Address\_Write cycles in the EPP mode

as (for example) CD-ROM drives, tape streamers, hard-disk drives, networks and so on. The ECP (Extended Capability Port) mode is an improved printer port which can be used with a new generation of printers and scanners. The most important difference between the Compatibility, Nibble and Byte modes on the one hand and the EPP and ECP modes on the other hand is that with the first group the software is responsible for handling the complete communications protocol, while with the second group the handling of data communications is in many cases almost completely implemented in hardware (in the form of 'super-I/O' chips). Thus with EPP mode a simple OUT instruction is all that is needed to dispatch data to a peripheral device.

### Compatibility mode

This mode defines a protocol which the PC can use to send data to the printer. This protocol is commonly known as the 'Centronics interface', named after the manufacturer which originally developed the interface. In this mode, data are first placed on the data lines and then the status lines are

checked to see whether the Busy line is active or the printer has reported an error. After this, a strobe pulse is issued. Figure 1 depicts the timing of the Compatibility mode. In practice, the maximum speed which can be achieved with this interface is 150 kbyte/s. Many of the integrated-circuit 1284 controllers use a FIFO to manage the data handling in the Compatibility mode. This arrangement is often described as 'fast Centronics' or 'parallel port FIFO mode'. If this feature is available, then the hardware takes care of generating the strobe pulses and manages the complete handshaking process. In this way it is possible to achieve data transfer rates of 500 kbyte/s. However, you must keep in mind that this feature is not part of the IEEE 1284 standard.

### Nibble mode

The Nibble mode is the method which is most commonly used when data must be sent from the outside world to the PC. It is often combined with the Compatibility mode in order to realize a bi-directional channel. Five lines of the standard parallel port are used to transfer data from a peripheral device

to the PC. The peripheral device uses these lines to send each data byte (8 bits) as two successive 4-bit nibbles. Figure 2 shows the timing diagram of Nibble mode. Since the ACK line is normally used to allow the peripheral device to communicate with the PC, the bits which are packed into each nibble are recovered from the status register, but they are not arranged here in a 'logical' order. The software thus has to do quite a bit of translation in order to rearrange the bits in the correct sequence. The second column of Table 1 shows how the SPP signal lines are used in the Nibble mode.

The Nibble mode is the most 'compute-intensive' with respect to the software. For this reason the data transfer rate is rather low: at most roughly 50 kbyte/s. Such a low data rate is a problem for fast peripheral devices such as LAN adapters and CD-ROM drives. The most important advantage of this mode is that it can be used on every PC (old and new).

### Byte mode

In later versions of the parallel port, the manufacturers switched over to chips which made it possible to use the printer port in both directions. With such an interface, a peripheral device can send data to the PC eight bits at a time. Splitting each byte into two successive transfers, as in the Nibble mode, is thus no longer necessary. The rate at which the PC can read in data with this mode is comparable to the rate at which it can write data to a peripheral device in the Compatibility mode. Column 3 of Table 1 shows how the SPP signal lines are used in the Byte mode.

### EPP mode

The Enhanced Parallel Port (EPP) mode was originally developed by Intel, Xircom and Zenith Data Systems as a parallel port which is compatible with the standard printer port but which has a higher level of performance. Intel built the protocol which is used for this mode into the 386SX chip set (82360 I/O chip). This development occurred before IEEE 1284 was initiated.

The EPP protocol had many advantages, and was quickly adopted by many manufacturers. A group of 80 manufacturers ultimately took the initiative to extend and promote the protocol. Subsequently, care was taken to see that this protocol was adopted by the IEEE 1284 group and incorporated into the standard as one

**Table 2. EPP register definitions.**

PortName	Offset	Mode	Read/Write
SPP Data	+0	SPP/EPP	W
SPP Status	+1	SPP/EPP	R
SPP Control	+2	SPP/EPP	W
EPP Address	+3	EPP	R/W
EPP Data	+4	EPP	R/W
Not Defined	+5...+7	EPP	

3 Address\_Write cycle,  
4 Address\_Read cycle.

The purpose of the data cycles is to exchange data between the computer and a peripheral device. The address cycles are used either for address, channel or control information or for commands. **Table 1** also shows (in column 4) how the signal lines are used in EPP mode. **Figure 3** shows the timing diagrams for an EPP

communication between the PC and the peripheral equipment. There are two types of cycles in the ECP protocol:

- 1 data cycle,
- 2 command cycle.

The command cycle can be further divided into two types: Run Length Count and Channel Address. Let's now see what these mean in practice.

In contrast to the situation with EPP, a standard register arrangement was proposed as part of the ECP protocol. This arrangement is described in the document "The IEEE 1284 Extended Capabilities Port Protocol and ISA Interface Standard", which was published by Microsoft. This document describes supplementary features and functions which fall outside the scope of the IEEE 1284 standard. In this regard it is worth mentioning the following: Run Length Encoding (RLE) data compression for computers, FIFOs for data channels in both directions, and DMA and programmed I/O for the computer.

With the aid of RLE, a data compression factor of 64:1 can be achieved. This is ideal for scanning and printing applications in which large blocks of identical information can occur in data files.

Channel Addressing is conceptually an extension of the addressing scheme used in EPP. This technique is used to allow multiple functions to be housed in a single physical enclosure. For example, consider the combination of a printer, fax and modem. Connecting a single piece of equipment to a single parallel port then effectively results in having three separate functional devices available: a printer, a fax and a modem. Thanks to the channel protocol, data can be received from the modem at the same time that the printer is busy printing out a document.

In the ECP mode a number of new functions are assigned to the signal lines of the SPP interface. **Table 3** shows the new register structures that are used in the ECP mode.

The Microsoft specification defines a number of common registers for IEEE

**Table 3. ECP register definitions.**

Offset	Name	Read/Write	ECP Mode	Function
000	Data	R/W	000-001	Data Register
000	ecpAfifo	R/W	011	ECP Address FIFO
001	dsr	R/W	all	Status Register
002	dcr	R/W	all	Control Register
400	cFifo	R/W	010	Parallel Port Data FIFO
400	ecpDfifo	R/W	011	ECP Data FIFO
400	tfifo	R/W	110	Test FIFO
400	cnfgA	R	111	Conf. Register A
401	cnfgB	R/W	111	Conf. Register B
402	ecr	R/W	all	Extended Control Register

**Table 4. ECP register modes.**

Mode	Description
000	SPP mode
001	Bi-directional mode
010	Fast Centronics
011	ECP Parallel Port mode
100	EPP Parallel Port mode
101	(reserved)
110	Test mode
111	Configuration mode

Data\_Write cycle and an EPP Address\_Read cycle.

One of the most important advantages of this type of port is that the whole data transmission can be handled by a single ISA I/O cycle. The transmission rate can thus range up to a maximum of 2 Mbyte/s. In this way the printer port can achieve a speed which is comparable to that of an interface on an ISA card.

### ECP mode

The most powerful mode used with the parallel port is the Extended Capability Port (ECP) mode. The protocol for this comes from Microsoft and Hewlett-Packard. It is intended to be a very advanced communication option between a PC and peripheral devices such as printers and scanners. The ECP mode allows high-speed bi-directional

of the improved modes.

There four ways in which data can be sent in the EPP mode:

- 1 Data\_Write cycle,
- 2 Data\_Read cycle,

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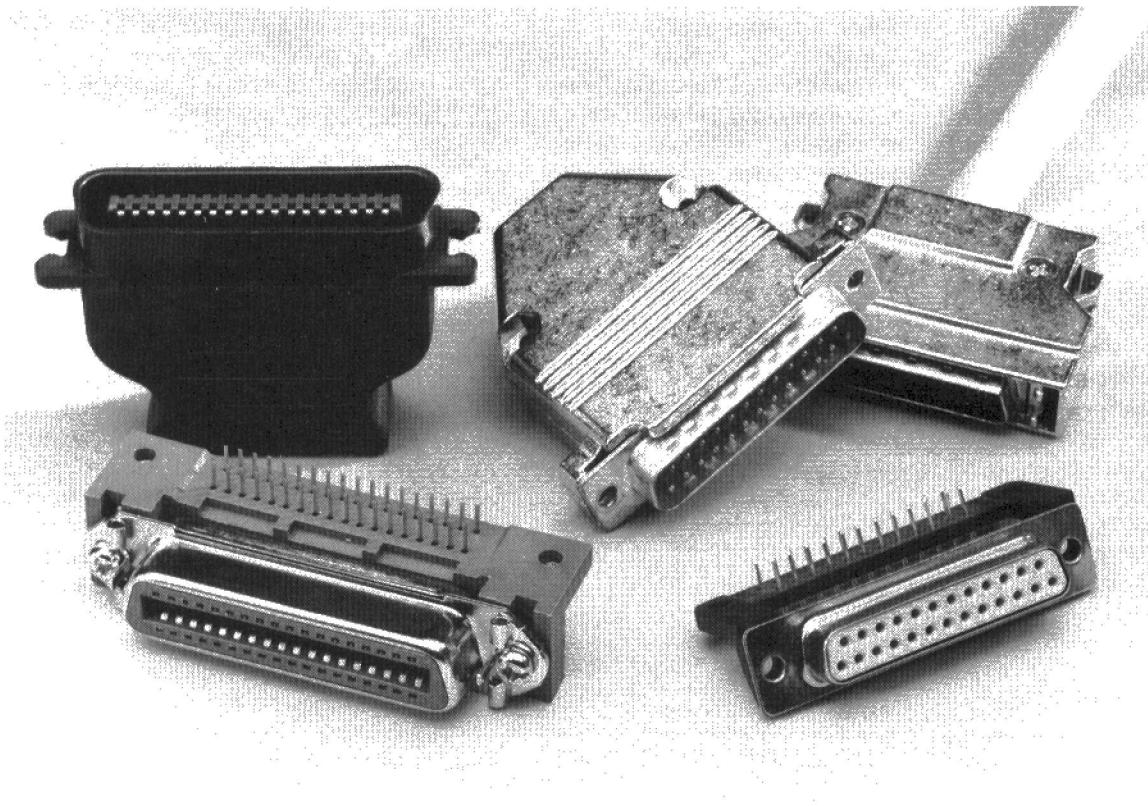


Figure 4. The three types of connectors which are allowed by the IEEE 1294 standard.

1284 adapters connected via the ISA bus and also support ECP. It additionally specifies a number of modes that the adapter must support. These are summarized in **Table 4**.

The ECP register model is comparable to that of a standard parallel port, but it also makes use of an important feature of the ISA interface. In the standard IBM architecture only the first 1024 register or I/O addresses are used. This is the address space starting at  $0x000_H$  and ending at  $03FF_H$ . Ten address bits (AD0:9) are required to address this region.

In order to keep costs down, the hardware of older-model ISA cards uses signals from the ISA bus to help in decoding the address. This 'automatically' limits the number of addressable registers to 1024. PCs that are more modern decode more address bits and thus have a larger I/O address space available. A consequence of this is that locations in the first 1K block of the address space can be doubly addressed, since the limited address-decoding logic of older-model ISA cards generates 'mirror' addresses in this block from higher-level addresses. Software can address the new register banks by adding 1024 ( $0x400_H$ ) to the base address which is used. The new addresses thus lie outside of the original 1K address region, but in fact they

are 'mirrored' back into this region. For example, selecting addresses  $0x378_H$  and  $0x778_H$  with newer types of ISA cards gives access to two different registers located in two different banks, while with older-model cards these two addresses will both access the same register.

The advantage of this technique (which is called *aliasing*) is that new cards can have 'invisible' registers and thus can increase the maximum number of available registers. With this approach, other I/O registers located on other cards will never be disturbed. In this way the new cards remain compatible with the older cards, which can only decode 10 address bits.

The ECP register model makes use of the aliasing technique. It defines six registers that use only three I/O addresses (see **Table 3**). Two registers located at addresses  $0x000_H$  and  $0x400_H$ , respectively, have somewhat different names and functions depending on the ECP mode in which they are used, as can be seen from the table. The fourth and fifth columns of **Table 3** list the various ECP modes and identify the functions these registers have for each mode. The actual mode must always be selected in advance by writing one of the mode codes to register  $0x402_H$ .

## Connectors

The IEEE 1284 standard does not limit itself to defining the structures of the ports and the electrical signals to be used. The mechanical specifications of the connectors to be used are also included in the standard.

Three different types of connectors (types A, B and C) are proposed in the standard. Type A is a 25-pin sub-D connector, which is long since a familiar feature of the PC. Type B is the well-known 36-position Centronics connector, which can be found on many printers. Type C, a miniature 36-pin connector with retaining clips, is especially intended for use in new designs. This last type of connector takes up less space on the circuit board, and it is easily attached and removed thanks to the retaining clips. An additional important advantage of this connector is that with it two additional signals are added to the interface: Peripheral Logic High and Host Logic High. These signals can be used to ascertain whether the equipment at the other end of the cable is powered on. In this way a certain degree of power management is made possible by the IEEE 1284 standard.

(982041)

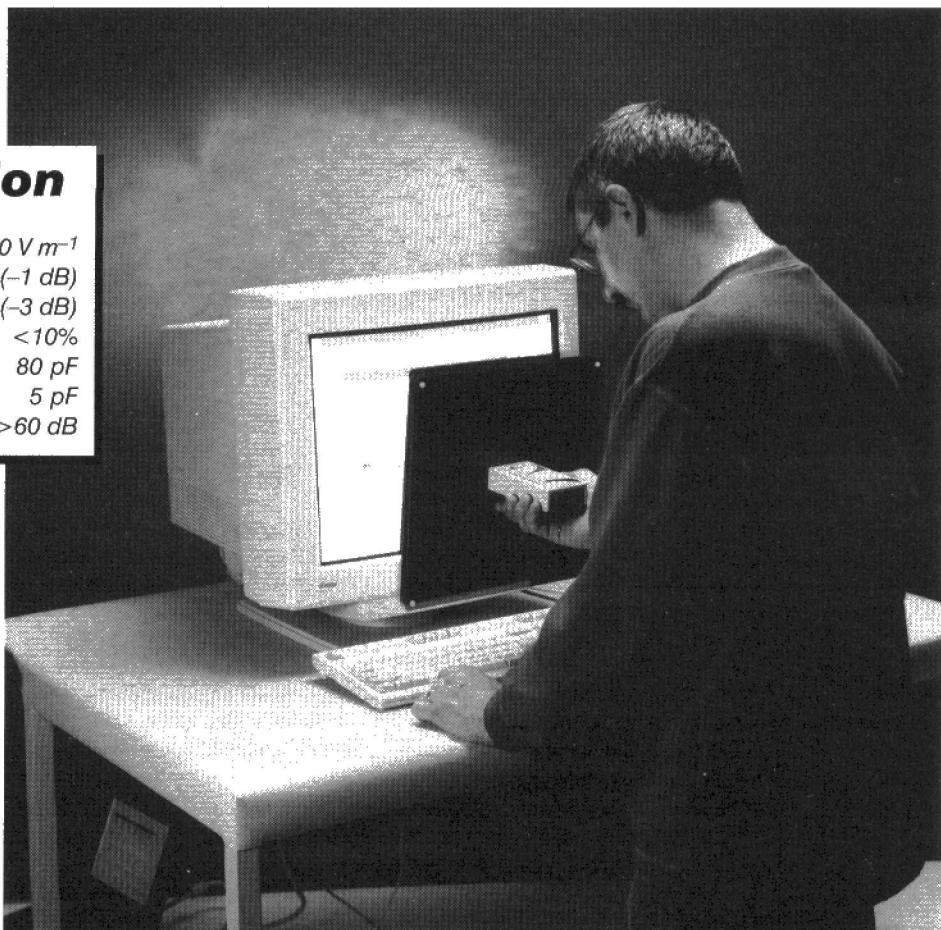


# E-meter

*to check the radiation  
from your VDU*

## Brief specification

Measurement range	10–100 V m <sup>-1</sup>
Frequency range	10 Hz – 2 kHz (-1 dB) 5 Hz – 5 kHz (-3 dB)
Measurement error	<10%
Sensor capacitance	80 pF
Input capacitance	5 pF
CMRR	>60 dB



Computer users may have noticed that nowadays there are guidelines as to the limits of radiation a monitor may produce.

This is sensible since there are people who believe that high field strengths may adversely affect our well-being. It is a fact,

however, that, although we all find ourselves constantly in electric fields, wherever we are in the world, there have as yet

been no reliably reported and proven cases of harm to the health of a human being. Nevertheless, most major manufac-

turers of computer displays make sure that their monitors meet MPRII/MPRIII Recommendations (although these are not mandatory anywhere). Put your mind at rest by ascertaining for yourself that the radiation of your monitor is well below what is believed to be a safe level.

Design by H. Bonekamp

Almost eighteen months ago, this magazine carried an article 'Magnetic-field meter', a small *H*-meter to check the presence or otherwise of alternating magnetic fields. In the present article, an *E*-meter is described to check the presence and strength of alternating electric fields.

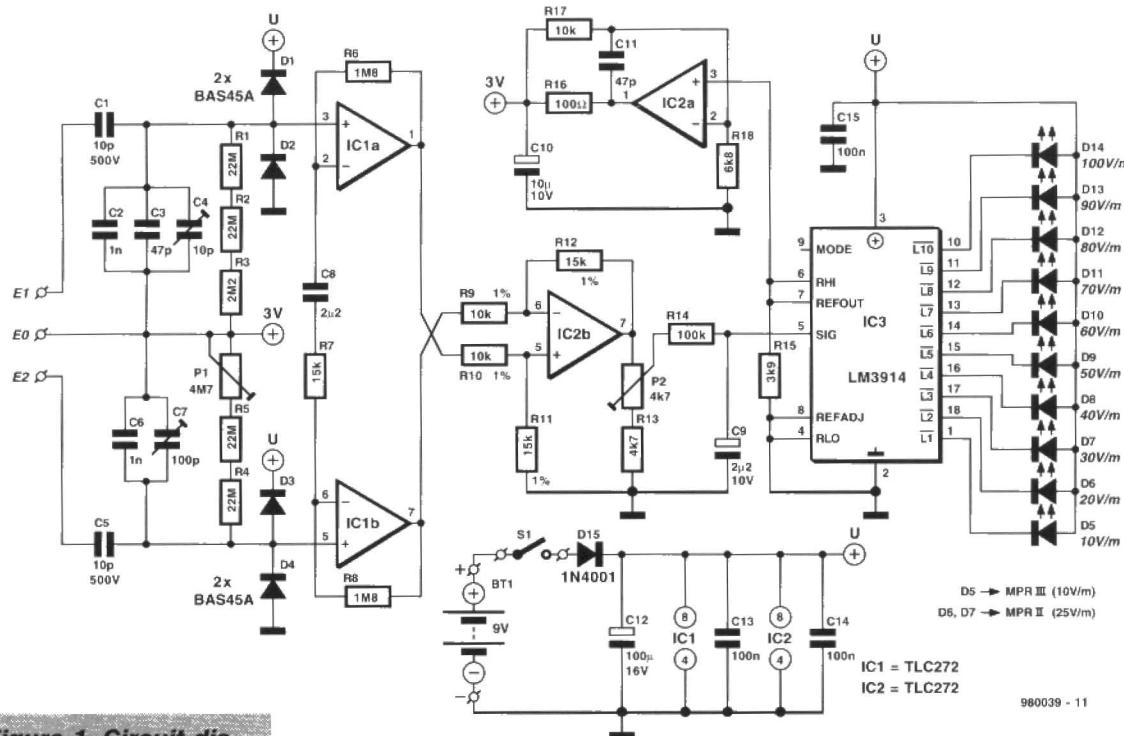
Like the *H*-field, the *E*-field is suspected of being harmful to our health,

conclusive studies that quantify the hazards, if any. But, of course, there is no harm in being cautious. When you are about to buy a monitor, you should know whether it meets MPRII or MPRIII. Buy it from a reputable supplier, or bring your *H*-meter and *E*-meter along and purchase the one with the lowest emission levels (see box).

people maintain that there must be some effect since, for instance, a pacemaker with an output of only 1 mV has a biological function, that is, to contract and expand muscles in the heart.

## CIRCUIT DESCRIPTION

The circuit of the *E*-meter, shown in Figure 1, consists basically of four sec-



**Figure 1.** Circuit diagram of the *E*-meter.

but there are no scientific studies that conclude that levels of these fields well above the MPRII levels (see box) are hazardous.

Sweden has been a leader in developing recommended electromagnetic emission standards for computer displays. In 1987, the Swedish National Board for Measurement and Testing introduced the first, non-mandatory testing procedures for monitors. Called MPRI, they were followed in 1991 by MPRII. These guidelines have generally been adopted by many major manufacturers of computer displays. Yet, even in Sweden, there is no consensus on the limits. The Board stresses that there are no proven biological reasons for limiting the radiation from monitors and that their guidelines are not based on health risks. Rather, the recommended limits are based on what is technically feasible to measure and on what is achievable now or in the foreseeable future.

## SAFETY FIRST

So, if a computer display meets the Swedish guidelines, is it safe? No one can say for sure, since there are no

## ELECTROMAGNETIC FIELDS

All equipment connected to a source of electricity and switched on generates electromagnetic fields. These fields can be separated into magnetic and electric fields, each of which can be a static or an alternating field. The circuit described in this article monitors alternating *E*-fields. These fields ensue when an apparatus is linked to the mains supply. Every mains outlet, cable, and equipment connected to them generates an *E*-field.

Of course, in a well-designed installation with good earth connections (obligatory in the UK), the field strength remains well within what are considered safe levels.

When a human being is within an *E*-field, his/her body behaves as an antenna, so that tiny voltages are induced in the body. Some people maintain that because of these they become more susceptible to colds and flu, and headaches or stress. It must, however, be stressed again that there is no scientific evidence that even very high field strengths are hazardous. Nevertheless, it is not clear what the effects are on human beings. Some

tions. The sensor is formed by a DIY air capacitor that is linked to the input stage, which is based on a capacitive attenuator. Because of the attenuation, the common-mode voltage may be well outside the limits of the power supply—here, some 300 V<sub>pp</sub>.

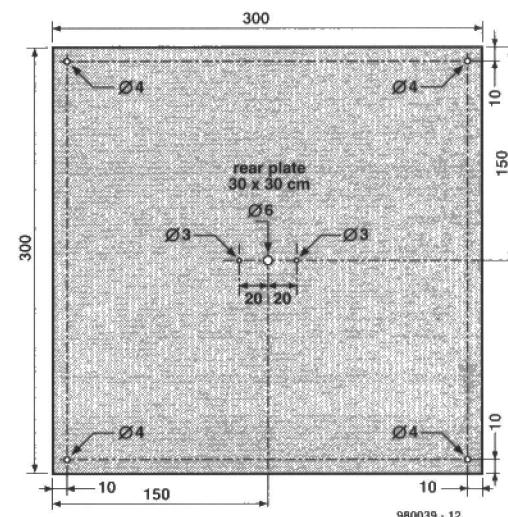
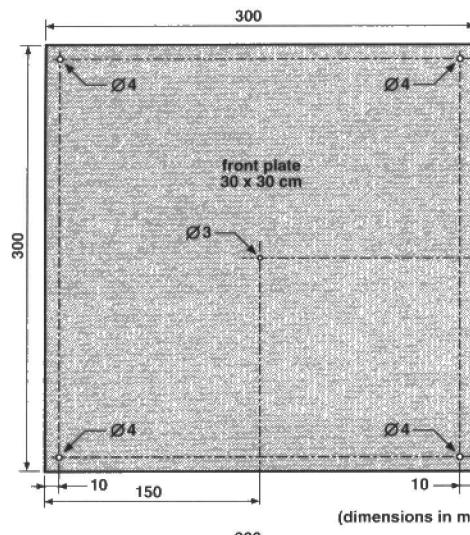
The attenuator is provided with a calibration point to enable a low input capacitance to be combined with a large common-mode suppression. The input capacitance must be low to ensure that the sensor is loaded as lightly as possible. Capacitive coupling with a physically large capacitance is used since this closely resembles a human being in the *E*-field.

The circuit is given a d.c. offset of about 3 V via resistors R<sub>1</sub>-R<sub>5</sub> and preset P<sub>1</sub>. This offset is used to set up operational amplifiers IC<sub>1a</sub> and IC<sub>1b</sub>.

So as to obtain good common-mode suppression and a balanced load from the sensor, a traditional instrumentation amplifier is used.

The d.c. amplification of the input stage is  $\times 1.5$  and its a.c. amplification,  $\times 361.5$ . Because of the low d.c. amplification, it is not necessary to provide compensation to counter the d.c. offset of the op amps.

2



**Figure 2.** Drilling diagram for the sensor plates. They are separated by five 10 mm nylon spacers to form an 80 pF air capacitor.

Op amp IC<sub>2b</sub> functions as a half-wave rectifier. This is possible because, although the op amp raises the difference between the signals at its -ve and +ve inputs, the asymmetric power supply allows only positive voltages to be generated. The level of amplification is set with P<sub>2</sub>. Network R<sub>14</sub>-C<sub>9</sub> averages the rectified signal. The direct voltage so obtained is applied to display driver IC<sub>3</sub>.

The output of the display driver feeds ten LEDs. The first of these, D<sub>5</sub>, lights when the input voltage reaches 125 mV, and the last, D<sub>14</sub>, when it reaches 1.25 V. This makes possible a meter scale gradated from 10 V m<sup>-1</sup> to 100 V m<sup>-1</sup>, which is more than ample for the purposes of the present meter.

Note that for emissions complying with the MPRII and MPRIII recommendations (which is the case with most modern VDUs) only the three lowest LEDs are required.

After it has been buffered and amplified, the reference potential of the display driver is also used as the common-mode voltage for the instrumentation amplifier.

Power for the meter is derived from a single 9-V (dry or rechargeable) battery. Diode D<sub>15</sub> protects the circuit against wrong polarity.

### CONSTRUCTION

The most demanding part of the circuit is the sensor, a DIY air capacitor. This is produced from two 30×30 cm sheets of aluminium cut and drilled as shown in Figure 2. The sheets are fastened together with four nylon screws, nuts and 10 mm long spacers: one at each corner. Nylon screws, nuts and

spacers are used since these do not affect the capacitance, which is about 80 pF.

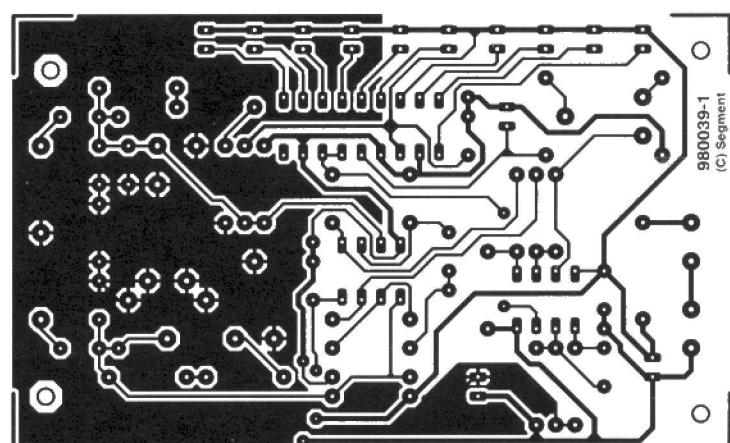
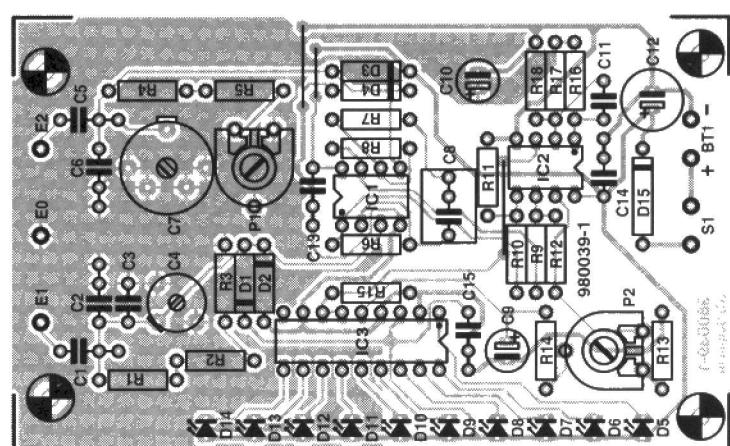
Populating the printed-circuit board (see Figure 3) should not present undue difficulties. Start by placing the wire bridges, followed by all passive components.

Use good-quality sockets for the ICs, since static charges can easily

damage the inputs of the operational amplifiers. Such damage is normally not immediately noticeable, but it does degrade the performance.

The board is fitted in the enclosure on 15 mm spacers to ensure that the LEDs protrude slightly through the lid of the enclosure. The battery is best fitted with some suitable tape or bluetack to the bottom panel of the enclosure.

3



**Figure 3.** Component layout of the single-sided printed-circuit board for the E-meter.

underneath the board (under IC<sub>2</sub>).

The sensor is fitted to the front panel of the enclosure with two 10 mm long and one 20 mm long M3 size nylon screws and nuts. Place a solder tag under one of the nuts at the back plate. For this purpose the back plate of the sensor has 3 mm holes at

#### Parts list

##### Resistors:

R<sub>1</sub>, R<sub>2</sub>, R<sub>4</sub>, R<sub>5</sub> = 22 MΩ

R<sub>3</sub> = 2.2 MΩ

R<sub>6</sub>, R<sub>8</sub> = 1.8 MΩ

R<sub>7</sub> = 15 kΩ

R<sub>9</sub>, R<sub>10</sub> = 10 kΩ, 1%

R<sub>11</sub>, R<sub>12</sub> = 15 kΩ, 1%

R<sub>13</sub> = 4.7 kΩ

R<sub>14</sub> = 100 kΩ

R<sub>15</sub> = 3.9 kΩ

R<sub>16</sub> = 100 Ω

R<sub>17</sub> = 10 kΩ

R<sub>18</sub> = 6.8 kΩ

P<sub>1</sub> = 4.7 MΩ preset potentiometer

P<sub>2</sub> = 4.7 kΩ preset potentiometer

##### Capacitors:

C<sub>1</sub>, C<sub>5</sub> = 10 pF, 500 V, 5%

C<sub>2</sub>, C<sub>6</sub> = 0.001 μF, metallized polyester (MKT), 5%

C<sub>3</sub>, C<sub>11</sub> = 47 pF

C<sub>4</sub> = 10 pF trimmer

C<sub>7</sub> = 100 pF trimmer

C<sub>8</sub> = 2.2 μF, metallized polyester (MKT)

C<sub>9</sub> = 2.2 μF, 10 V, radial

C<sub>10</sub> = 10 μF, 16 V, radial

C<sub>12</sub> = 100 μF, 16 V, radial

C<sub>13</sub>-C<sub>15</sub> = 0.1 μF, high stability

##### Semiconductors:

D<sub>1</sub>-D<sub>4</sub> = BAS45A (Philips)

D<sub>5</sub>-D<sub>7</sub> = LED, green, high efficiency

D<sub>8</sub>-D<sub>10</sub> = LED, orange, high efficiency

D<sub>11</sub>-D<sub>14</sub> = LED, red, high efficiency

D<sub>15</sub> = 1N4001

##### Integrated circuits:

IC<sub>1</sub>, IC<sub>2</sub> = TLC272CP

IC<sub>3</sub> = LM3914N

##### Miscellaneous:

BT<sub>1</sub> = 9-V battery with terminal clips

S<sub>1</sub> = single-pole on/off switch

Enclosure = Bopla E430 (from Phoenix Mecano Ltd, phone 01296 398 855) or similar

Aluminium sheet, 1 mm thick, 2 off 300×300 mm

4 off M4 nylon screw, 15 mm long

4 off M4 nylon nut

1 off M3 metal screw, 15 mm long

2 off M3 metal screw, 10 mm long

4 off M3 metal screw, 20 mm long (for board mounting)

4 off spacers, 15 mm long (for board mounting)

5 off M3 nut, nylon or metal

5 off nylon spacer, 10 mm long (for sensor)

2 off solder tag, 3 mm

Insulated circuit wire as required.

PCB Order no. 980039 (see Readers' services towards the end of this issue)

## MPRII/MPRIII Recommendations

Magnetic fields	ELF (5 Hz - 2 kHz)	<250 nT*
	VLF (2 kHz - 400 kHz)	<25 nT*
Electric fields	ELF (5 Hz - 2 kHz)	<25 V m <sup>-1</sup>
	VLF (2 kHz - 400 kHz)	<2.5 V m <sup>-1</sup>

\*nT = nano Tesla (1 Tesla = 1 Weber m<sup>-2</sup>)

For the MPRII recommendations, these limits are measured at 48 different positions around the monitor at a distance of 50 cm. For the MPRIII recommendations, the measurements are taken at a distance of 30 cm from the monitor, also at 48 positions.

either side of the 6 mm centre hole. These three holes should also be drilled in the front panel of the enclosure at the appropriate positions. The 20 mm long screw should pass through a 10 mm nylon spacer and the front plate of the sensor where it is fastened with a nylon nut, under which a solder tag is placed. The nylon fasteners ensure electrical isolation of the two plates.

The front plate is linked to input E<sub>1</sub> via a short length of insulated circuit wire from the solder tag under the central fixing nut. The rear plate is linked to input E<sub>2</sub> via a short length of insulated circuit wire from the solder tag under one of the fixing nuts. The photograph of the completed prototype in Figure 4 shows how it is all done.

Finally, fit the on/off switch on the front panel of the enclosure.

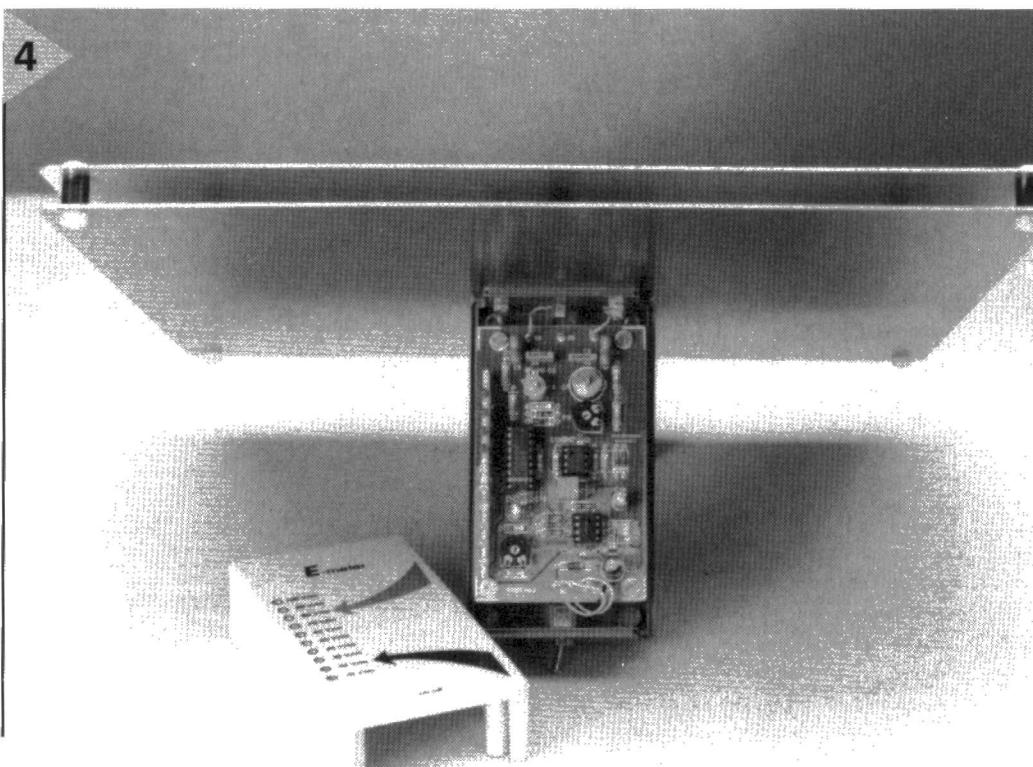
## CALIBRATION

Ideally, a function generator and a digital multimeter are required for setting up the instrument. If a function generator is not to hand, a bell transformer may be used—see later.

To ensure good common-mode suppression, the attenuators must be well balanced. Below frequencies of about 100 Hz the resistors are dominant, at higher frequencies, the capacitors.

Connect the multimeter, set to a relevant direct voltage range, across C<sub>9</sub>. Short-circuit E<sub>1</sub> to E<sub>2</sub> and connect the function generator between E<sub>1</sub> and E<sub>0</sub> (earth).

Figure 4. Photograph of the completed prototype.



Apply a sinusoidal signal at a frequency of 1 kHz and maximum output. Turn first C<sub>7</sub> (coarse) and then C<sub>4</sub> (fine) for minimum reading on the multimeter.

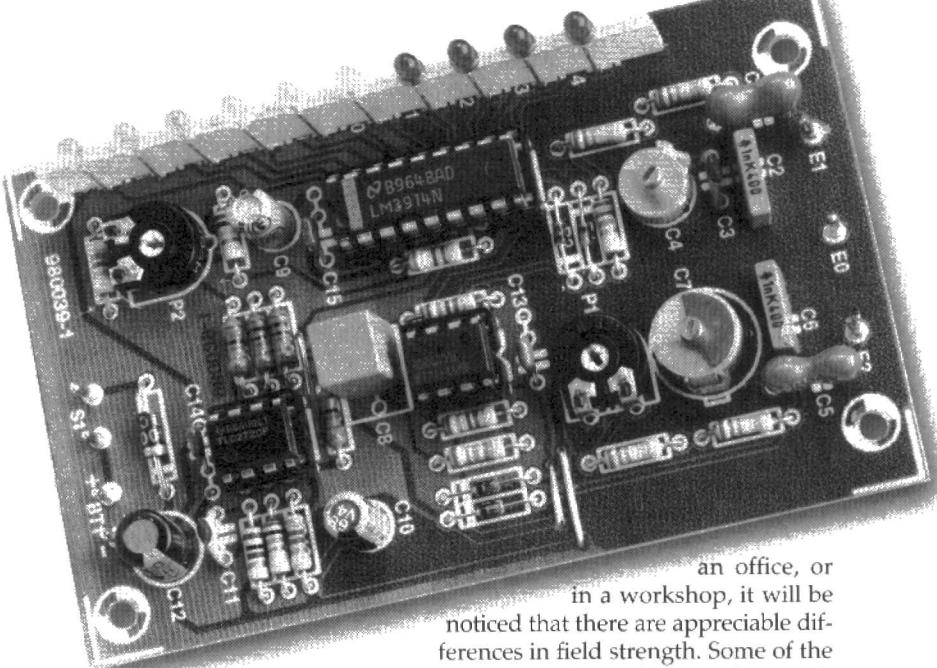
Lower the frequency to 10 Hz and adjust P<sub>1</sub> for minimum reading on the multimeter.

Remove the short-circuit from E<sub>1</sub> and E<sub>2</sub> and connect the function generator between these terminals. Connect the multimeter, set to an appropriate alternating voltage range, in parallel with the function generator output, making sure that the leads of the multimeter are not in the vicinity of the attenuators (so as to avoid crosstalk). Set the output of the function generator to 1 V rms and adjust P<sub>2</sub> until D<sub>14</sub> just begins to light.

If a function generator is not available, use a 12 V bell transformer. Short-circuit E<sub>1</sub> to E<sub>2</sub> and connect the secondary of the transformer between these terminals and earth (E<sub>0</sub>). Connect the multimeter, set to an appropriate direct voltage range, across C<sub>9</sub>.

Turn first C<sub>7</sub> (coarse), then C<sub>4</sub> (fine) and finally P<sub>1</sub> for minimum reading on the multimeter.

Remove the short-circuit from E<sub>1</sub> and E<sub>2</sub>. Connect the secondary of the transformer across a 1 kΩ potentiometer. Link the wiper and one of the



other terminals of the potentiometer across E<sub>1</sub> and E<sub>2</sub>. Connect the multimeter, set to an appropriate alternating voltage range, across E<sub>1</sub> and E<sub>2</sub>. Adjust the potentiometer until the meter reads 1 V rms. Turn P<sub>2</sub> until D<sub>14</sub> just begins to light.

If it appears that the range of C<sub>7</sub> is not large enough (which may happen when the tolerance of C<sub>1</sub>, C<sub>2</sub>, C<sub>5</sub> or C<sub>6</sub> is too large), alter the value of C<sub>3</sub> by trial and error.

During measurements of the E-field at home, at school or college, in

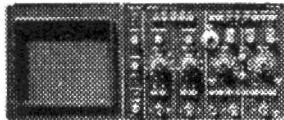
an office, or in a workshop, it will be noticed that there are appreciable differences in field strength. Some of the stronger fields may be caused by inadequate or faulty earthing.

## TESTING YOUR VDU

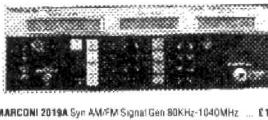
The alternating electric field of a VDU is a maximum when the background is a bright white. This can be set easily on most modern monitors.

If the VDU meets the recommendations of MPRII, D<sub>7</sub> will light at distances between the meter and VDU of up to 50 cm. The recommendations of MPRIII specify this distance as 30 cm; only D<sub>5</sub> should then light. [980038]

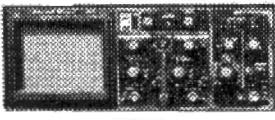
## HOW DOES YOUR EQUIPMENT MEASURE UP? AT STEWART OF READING THERE'S ALWAYS 'SCOPE FOR IMPROVEMENT!



**PHILIPS PM3217** (This is a proper scope)  
Dual Trace 50MHz Delay Sweep Incl 2 Probes  
£400



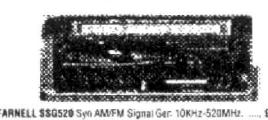
MARCONI 2018A Syn AM/FM Signal Gen 80KHz-1040MHz £1800  
MARCONI 2018A Syn AM/FM Signal Gen 80KHz-1640MHz £1980  
MARCONI 2020A Syn AM/FM Signal Gen 80KHz-520MHz £2800  
MARCONI 2020A Syn AM/FM Signal Gen 104KHz-1024MHz £1750



**HC3502**  
Dual Trace 20MHz 5mV-20V/Div; 0.2μ Secs - 0.5 Secs/Div; X-Y; X5 magnifier; TV Sync etc  
Hardly Used £150 Un-used £200



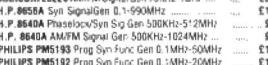
**THE CLASSIC TEKTRONIX 400 SERIES**



FARWELL SG520 Syn AM/FM Signal Gen 10KHz-520MHz £325  
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MARCONI 4311 Programmable Sweep 10MHz-20GHz £4500  
MARCONI 4302C AM/FM Signal Gen 100Hz-1GHz £2000  
H.P. 8655A Syn Signal Gen 0.1-990MHz £1500  
H.P. 8640A Phase Noise Syn & Gen 500KHz-52MHz £750



H.P. 8640A AM/FM Signal Gen 500KHz-1024MHz £650  
PHILIPS PM5193 Prog Sine/Func Gen 0.1MHz-50MHz £1500  
PHILIPS PM5192 Prog Sine/Func Gen 0.1MHz-20MHz £1000  
H.P. 3325A Syn Function Gen 21MHz £1250  
PHILIPS PM5134 Sweep Func Gen 0.001Hz-20MHz Sine/Sq/Tn £400  
PHILIPS PM5132 Sweep Func Gen 0.1Hz-2MHz Sine/Sq/Tn £250



FLUKE 770MM 3.5 digit with  
With All magnification, TV Tdg etc etc. Lots of  
Carrying Case & Leads £60



RACAL COUNTERS  
9978 10Hz-560MHz £125  
9916 10Hz-520MHz £150  
9904 DC-50MHz £80



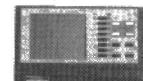
RACAL 1998 Counter 1.3GHz £650  
RACAL 1991 Counter/  
Timer 1.6MHz £450  
RACAL 1990 Counter 120MHz £300



SOLARTRON 7150 DMM 6.5 digit £EE£450  
SOLARTRON 7150 DMM 6.5 digit £EE£300  
True RMS

With All magnification, TV Tdg etc etc. Lots of  
specification

## LOOK — BRAND NEW OSCILLOSCOPES - NEVER USED - LIMITED STOCK



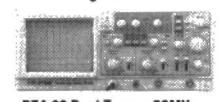
**DMS 3850A Digital Storage/DMM**  
Handheld LCD display. 2 Channel 30Ms/s. Auto range 4 Digit  
DMM/Capacitance/frequency counter. Battery operation or  
external 7.5-9.5V DC ie. AC adaptor (not supplied). RS232  
comes in Black. Carrying Case complete with 2 scope  
probes: DMM leads; Manual.

For Only £400



**DTS 40 Digital Storage**  
Dual Trace 40MHz 20 MS/s. Storage. Cursors +  
On screen readout. Sweep Delay; Interface etc etc.  
Supplied unused in original box complete with 2  
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specification

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Farwell H60/25 0-60 Volts 0-25Amps £400  
Farwell TS70MK2 70 Volts 5Amps 35Volts, 10Amps £200

Farwell L12-10C 0-12 Volts 0-10Amps £175  
Farwell L12-10C 0-12 Volts 0-10Amps £160

Farwell LT30-1 0-33 Volts 0-2 Amps twice £130  
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Thurby PL3210 0-30Volts; 0-2Amps GPIB Digital £110

Many More Power Supplies Available

## Used Equipment - GUARANTEED. Manuals supplied.

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## New & Hardly Used



100KHz-100MHz; FM 0-100KHz; Output -19dB-  
99dB AM 0-60%; 32 Preset Memory.

Digital Display Frequency & Output.

Used £450 Un-used £750

PANASONIC VP7637A STEREO SIGNAL GENERATOR

Generates Broadcast FM-RDS/ARI. Preset memory; GPB

Used £400 Un-used £700

KENWOOD FL180A WOW/FLUTTER

METER 0.003-10%; Freq 3KHz-  
3.15KHz RMS/AVERAGE/PEAK.

Weighted Filters. Digital Display of

rpm. 4 digit Freq Counter 0.01KHz-  
9.999KHz/0.01KHz-55KHz).

Used £400 Un-used £500

POWER SUPPLY Model HSP3010

30Volts; 0-10 Amps Current Limiting.

2 Meters.

Used £160 Un-used £200

AMAZING VALUE £400

D 30Volts; 0-10 Amps Current Limiting.

2 Meters.

Used £160 Un-used £200

GOODWILL GVT427 DUAL CHANNEL AC MILLIVOLT METER

10V/300V in 12 Ranges

Ranges 0.1% Low

Distortion 5 Steps Output

A attenuator. Un-used £80

GOODWILL GFC 8010G

FREQUENCY COUNTER Range

1Hz-120MHz 8 Digital Display

15mV RMS Sensitivity

Un-used £75

ANALOGUE MULTIMETER Model HC260TR AC/DC

Volts DC Current 10Amps; 17 Ranges; Continuity

Buzzer; Transistor Tester

Un-Used £15

STEREO AUDIO BALANCE TO UNBALANCED CONVERTOR

ie For Car Radio Servicing

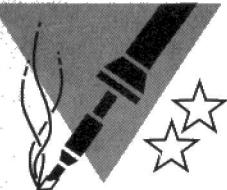
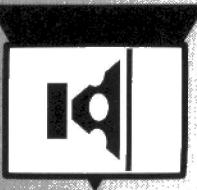
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# IC tester

## **Part 2: menu structure and test-vector building**

Last month we gave you the low-down on the hardware aspects of this powerful and versatile IC tester. In this second and concluding instalment, we turn to programming matters.

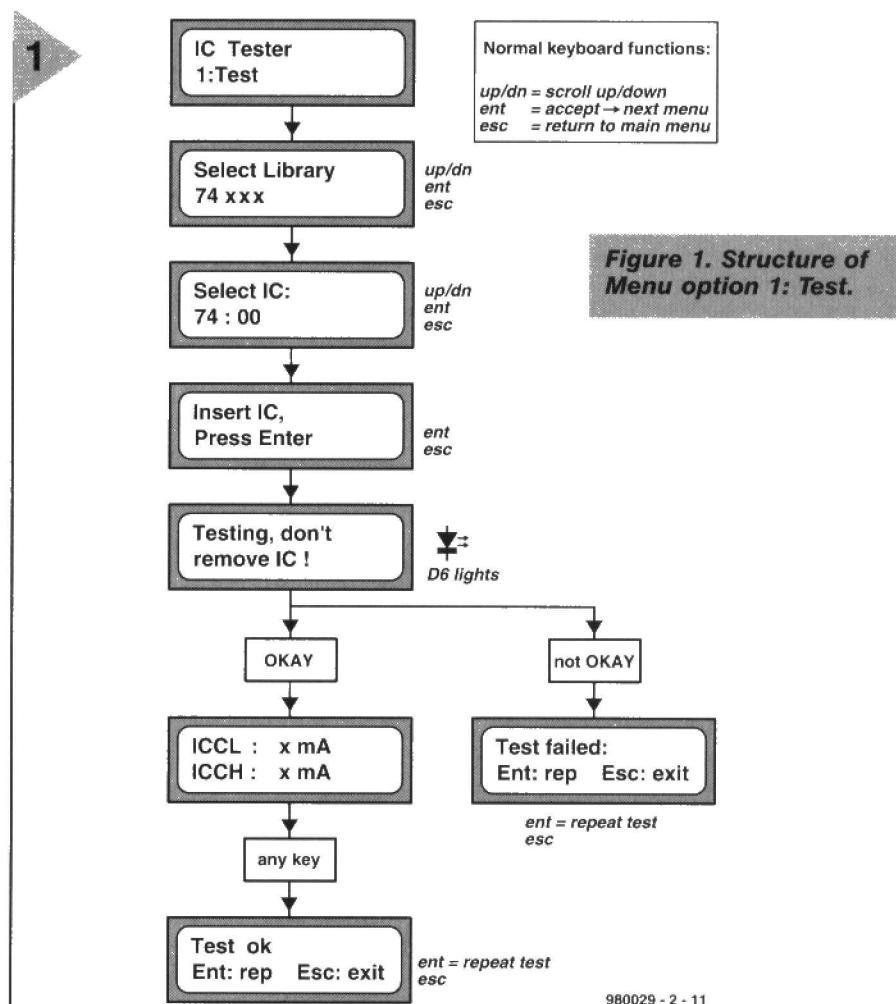
To be able to apply the information presented in this instalment, you have to have a working IC tester available, together with all the files found on the diskette with order number 986014-1 or CD-ROM 986001-1 (see further on). The tester is very likely to function properly if the message

## IC Tester 1:Test

appears on the LCD when you switch the power on. However, this project features a number of clever hardware checking options. Although you may not need to do any hardware checking at all, the relevant routines are briefly mentioned further on. For now, it is assumed that the tester works properly.

## **MENU STRUCTURE**

As already mentioned in last month's instalment, you are looking at a test instrument which offers three communication channels with the real world: a keyboard, an LCD and a serial computer interface. Throughout the operation of the IC tester, menus are used to interact with you, the user. Selecting from the plethora of functions offered by the instrument is basically very simple and easy to learn once you know



the functions of the (few) keys on the keyboard. Fortunately, the use of these keys is consistent in most menus. To help you stay oriented, the structure of each of the major sub-menus offered by the tester is shown in **Figures 1 through 8**. Where a key has a non-standard function, this is indicated separately.

Many of you will be perfectly happy to use the '1:Test' menu most of the time, or the '3:Retest' menu if you are looking at a pile of identical ICS which should be subjected to a go/non-go test.

## TEST VECTOR FILE

From here on, we are addressing the

more advanced users among you who require a deeper knowledge of the way the instrument uses built-in software to test logic integrated circuits. For a good understanding of the hardware/software interaction, it is necessary to analyse the structure of the file Test Vector File which is permanently stored in the system EPROM, together with the program executed by the microcontroller.

A copy of the test vector file which is compiled, converted to binary and then stored in the 'default' system EPROM (order code 986507-1) may be found on the project diskette, order code 986014-1, as well as on the '*μP-μC Hard & Software 97-98'* CD-ROM, order

Design by L. Lamesch

code 986001-1 (look in the subdirectory /INT/BIN). The file is called VECT.TVC, and contains all information the system needs to check the massive amount of ICs listed in Table 1 in last month's instalment. For now, let's load 'VECT.TVC' into a word processor, and examine the syntax used. What do all these keywords mean?

;  
Comment delimiter. All characters following the semicolon are treated as comment, and ignored by the system.

#### LIBRARY lib\_name

Defines the start of an IC library. This should be the first keyword in the .TVC file (except comment, of course). All IC types which follow this keyword belong to the library with the name 'lib\_name'. The name of the library may consist of up to 15 characters. There is no limit to the number of libraries in a .TVC file.

#### NAME ic\_name

Defines the start of IC data, and launches the test vector set for the IC with the name 'ic\_name' (max. length is 15 characters). There is no limit to the number of ICs in a library. The end of the test vector set is marked by the next occurrence of 'NAME', 'LIBRARY', or the end of the .TVC file.

#### CHILD parent\_ic\_name

If an IC employs the same test vectors as one already defined, it is sufficient to identify it as a 'child' of a 'parent'. For example, the 74:132 has the same function and pinout as the 74:00, except that the gates are of the Schmitt trigger type (which is not recognised by the tester). A 74:132 is defined as follows:

```
NAME    74:132 ;define new IC
CHILD   74:00 ;declare as 74:00
          offspring
```

A parent may have up to 100 children.

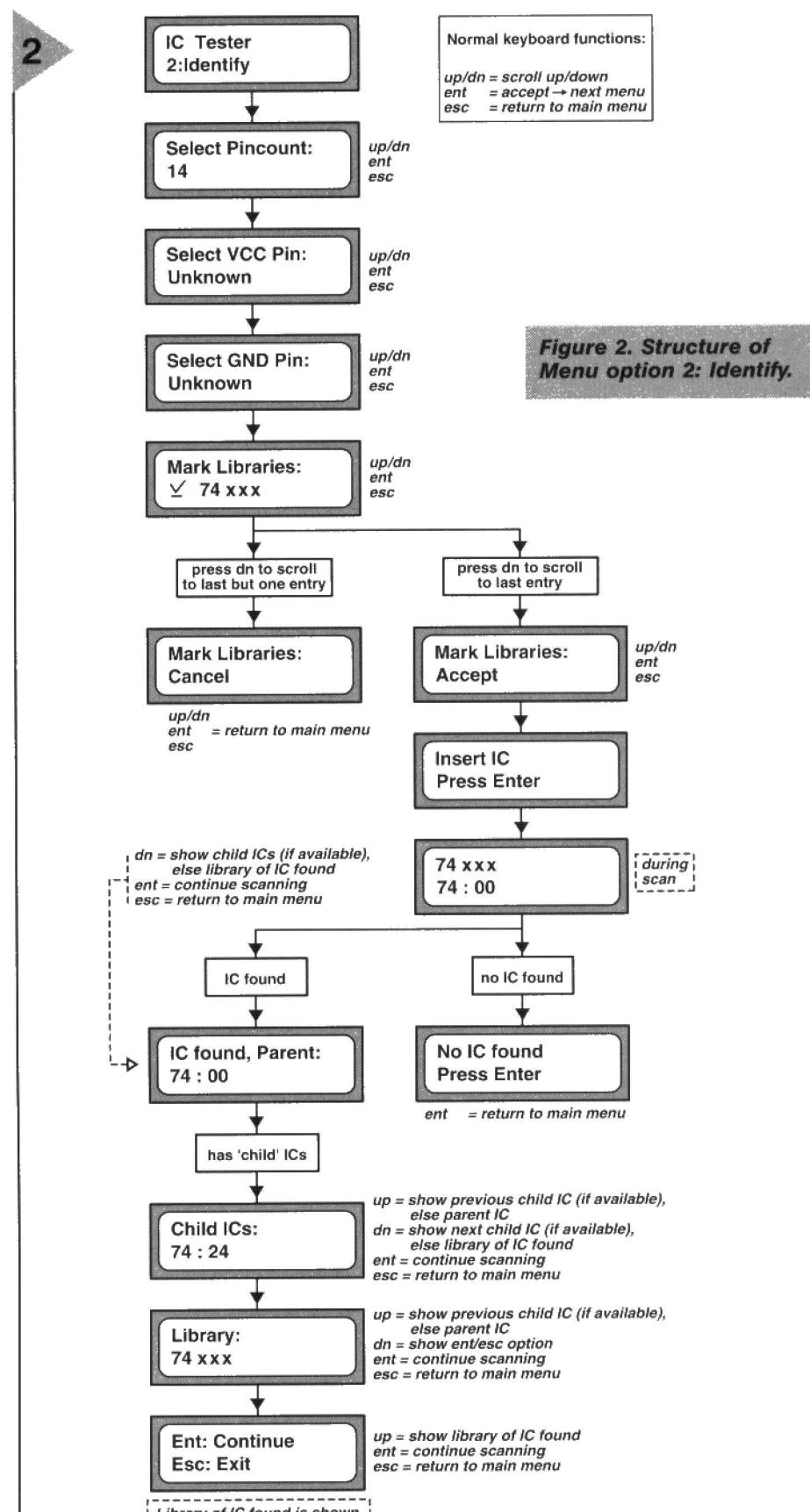
#### PINS pin\_count

Unless a certain IC is a 'child', its test vectors have to be defined. In that case, the first keyword to use is always 'PINS' which defines the number of pins on the IC.

#### PINORDER pin\_order

Links the individual IC pins to the columns that supply the test vectors. 'PINORDER' may only follow 'PINS', and the pins are identified using their pin numbers. Individual pin numbers should be separated by a space character. All IC pins have to be identified in 'pin\_order', including pins which are not tested.

#### PINDEF pin\_definition



980029 - 2 - 12

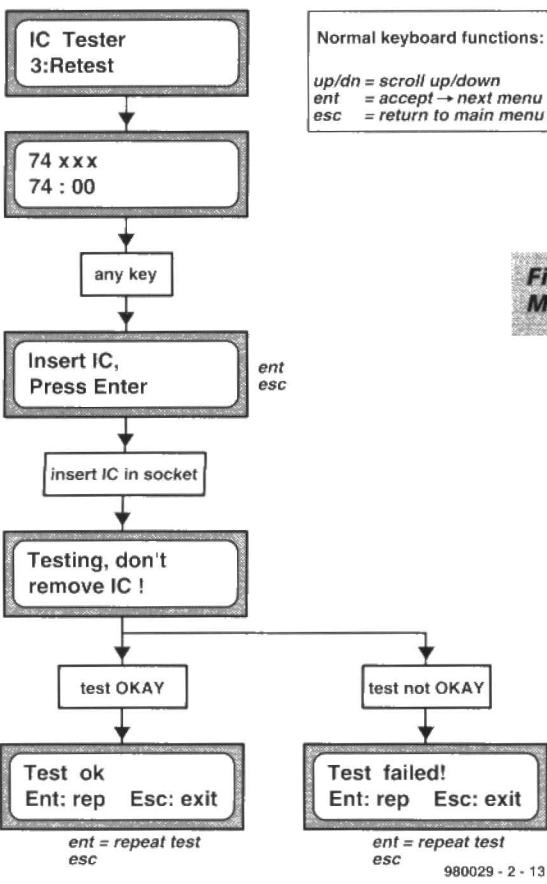
This defines the function of each individual pin. The following functions are available:

- o output
- i input
- g ground pin
- v Vcc (+supply) pin

The individual pin functions may be

separated by spaces (not obligatory, though), and all pins must be included in 'pin\_definition'. Pins which should not be tested are defined as outputs ('o'), and not tested in the 'VECT' line ('x'). 'PINDEF' should precede the first 'VECT'. After a 'VECT' line, the pin functions may be redefined using 'PINDEF'.

3

**VECT test\_vector**

A test vector may consist of the following elements:

- 1 output pin: check if pin is at 1;  
input pin: apply 1 to pin.
- 0 output pin: check if pin is at 0;  
input pin: apply 0 to pin.

z test if pin is at high impedance.  
x do not test this pin.

The individual elements may be separated by spaces (not obligatory). If a pin is defined as 'GND', it should have a 0 at the relevant position in the test

vector. Likewise, 'VCC' should be matched with a 1.

**REPEAT count, ENDR**

This keyword allows a loop to be implemented, containing test vectors (VECT) and pin function definitions (PINDEF). The loop is repeated 'count' times. Each loop has to be terminated with an 'ENDR' keyword. Nested loops are not allowed.

**PULL on\_off**

This keyword tells the IC tester hardware to connect the IC outputs to pull-down resistors during the test (on\_off = 1) or not (on\_off = 0). When on\_off is at 0, the outputs are continuously loaded by a pull-up resistor, and testing for a high-Z state is not possible.

**ICCL**

When this instruction is encountered, the regulated power supply measures the IC supply current. After the test, the supply current is indicated as 'ICCL'. 'ICCL' may only be used once for any one IC.

**ICCH**

When this instruction is encountered, the regulated power supply measures the IC supply current. After the test, the supply current is indicated as 'ICCH'. 'ICCH' may only be used once for any one IC.

The following points should be noted when writing your own test vectors for ICs not included in the default library.

► All IC inputs have to be made logic 0 and logic 1 at least once, in a manner that ensures that this change can be detected on at least one IC output.

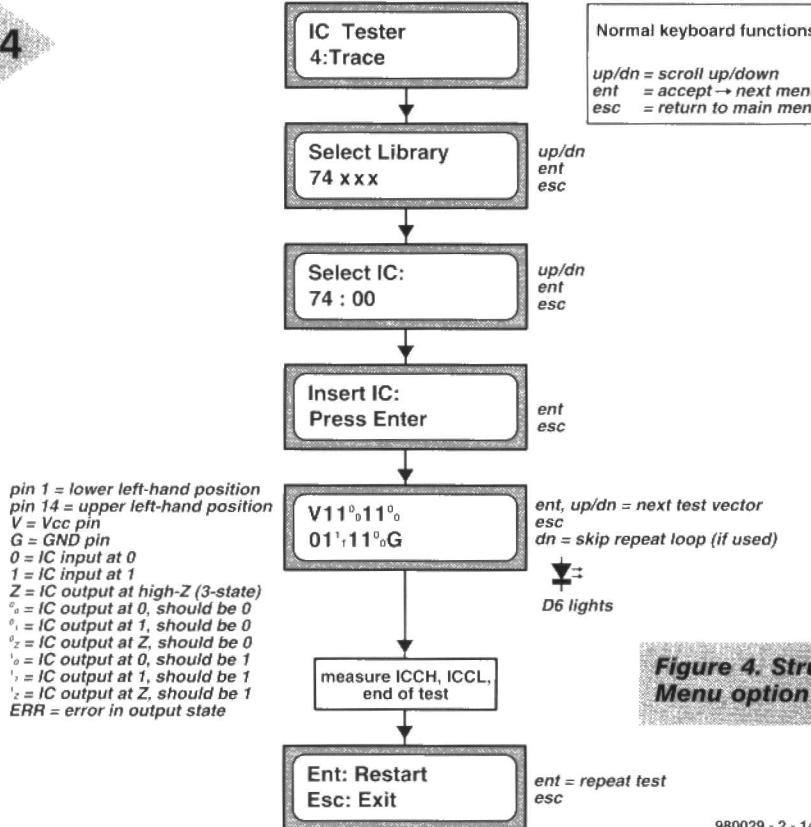
► All IC outputs have to go 0 and 1 at least once during the test, and also 'Z' (high-impedance or tri-state) when an output can assume this state.

► With ICs having a sequential internal circuit, IC inputs driving the clock input of a register flip-flop may not change state in unison with inputs of these flip-flops, if this transition equals the active edge of the clock input. For example, the clock input of a 74:74 may not change from 0 to 1 when the level at the data input changes at the same time. This proviso also applies to clock and enable inputs of synchronous counters.

► If an enable input of a latching flip-flop toggles, the level at the data input of the flip-flop is not allowed to toggle at the same time. This applies to rising as well as falling pulse edges.

To close off this section, Figure 9 shows

4



an example of a set of test vectors written for the type 4040 CMOS 12-stage ripple-carry binary counter. Although not all compiler keywords are used, the example is still useful to unravel the structure of the vectors in relation to the internal operation of the IC. A pinout diagram is included for your convenience. Note how the 'repeat' instruction is used to toggle the logic level at the clock pulse input (cp). Depending on the number of clock pulses applied in this way, a particular IC output ( $Q_x$ ) should go high. The hardware monitors this output, and its level is compared with that stated by the test vector. For example, a logic 1 should occur on output Q8 of the 4040 after 128 clock pulses. If this logic one is not measured after the 'endr' instruction, in other words, if the response of the IC under test does not match the test vector after 'endr', the IC is identified as faulty, and may be binned! Comment is also used in this test vector script: the fourth line contains the logic labels of the IC pins. Note that some manufacturers of the 4040 start with output label Q1 rather than Q0 as indicated by the comment. This does not affect the operation of the IC, however.

More IC test vector scripts and internal diagrams are given on this month's *Datasheets*.

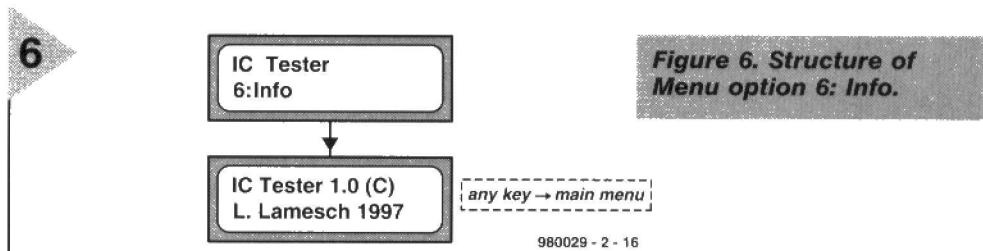
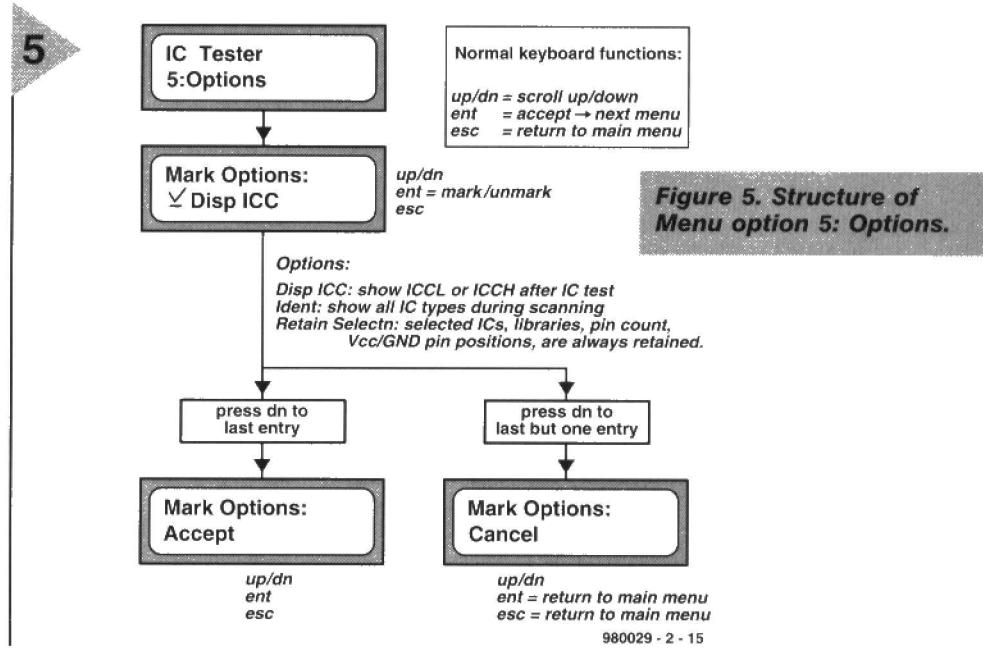
## TEST VECTOR COMPILING AND DEBUGGING

The purpose of analysing the master test-vector file as we just did is to enable you to write your own test scripts for ICs not included in the default library (see Table 1 in part 1). In principle, you only need a datasheet of the IC to reason how it *should* work. Eventually, you may want to add the new test vectors to the ones already available in 'vect.tvc', and burn the lot into a new system EPROM. The programs and general procedures to do so will be described below. Remember that all of the information presented below may be totally academic to you if you are satisfied with the collection of ICs in the default library.

Do not launch the programs directly from the floppy disk. First run *CHECK 1* from the DOS prompt as indicated on the floppy to make sure the data is intact and virus-free. Next, copy all files on the floppy to a suitably named subdirectory on the hard disk.

### *ICTVC.EXE*

This is the **Test Vector Compiler**. Its function is to turn a test vector source file (like *VECT.TVC*) into a test vector binary file. Next, the latter file has to be appended to the microcontroller program, *ICT.BIN*, to create a large binary file that can be burned into an



EPROM. File appending, by the way, is achieved with the aid of the DOS command *copy ict.bin+vect.out /b eprom.bin*.

The compiler is invoked by typing

*ICTVC [source file.TVC]*

For example,

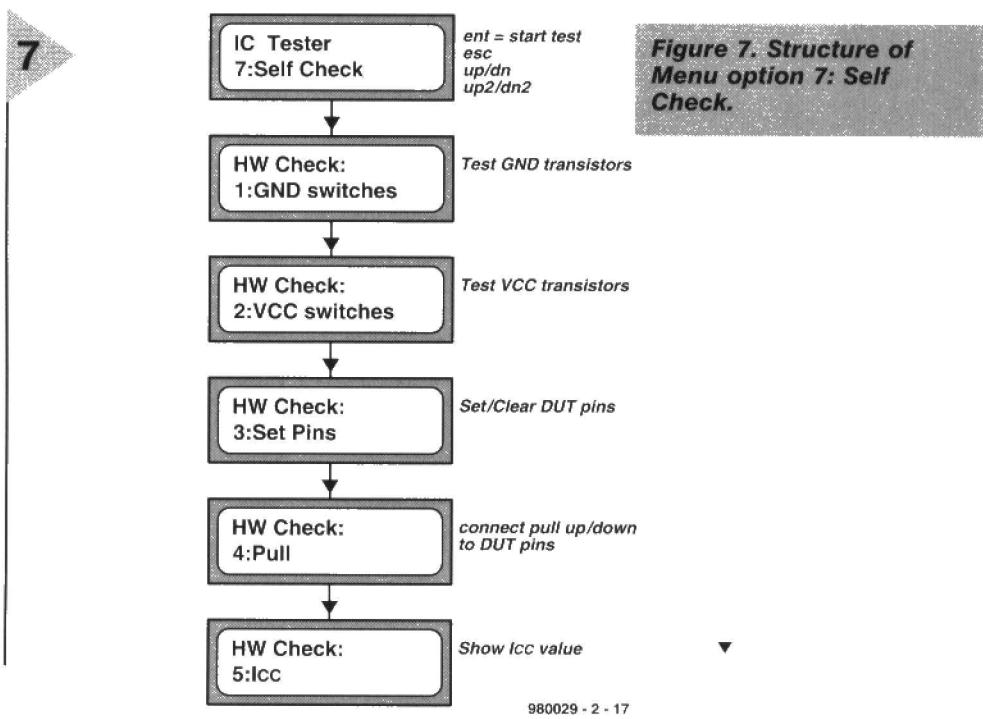
*ICTVC VECT.TVC*.

It generates the following files:

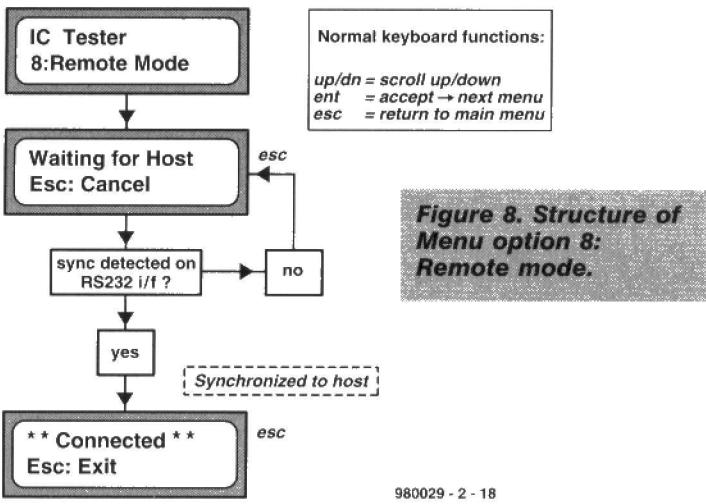
TVC.OUT: test vector file (binary);

ERR.OUT: error report;

LIST.OUT: list-file containing information on the source file, binary file, a copy of the source file with line num-



8



**Figure 8. Structure of Menu option 8: Remote mode.**

9

```

name      4040
; 12-bit CMOS ripple carry counter
pins     16
pinorder 10 11 1 15 14 12 13 4 2 3 5 6 7 9 8 16
; /cp mr q11 q10 q9 q8 q7 q6 q5 q4 q3 q2 q1 q0 gnd vcc
pindef   I I 0 0 0 0 0 0 0 0 0 0 0 0 0 0 G V
vect      0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 4
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
endr
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 8
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
endr
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 16
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
endr
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 32
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
endr
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 64
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
endr
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 128
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
endr
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 256
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
endr
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 512
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
endr
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
repeat 1024
vect      0 0 0 X X X X X X X X X X X X X X 0 1
vect      1 0 0 X X X X X X X X X X X X X X 0 1
endr
vect      0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
vect      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
iccl ; measure IC current
icch ; measure IC current
  
```

bers added as well as the bytes generated from each line;

TMPOUT: temporary file used by ICTVC.EXE.

Any errors occurring during the compilation process are recorded in ERR.OUT only. They do not appear on the PC screen.

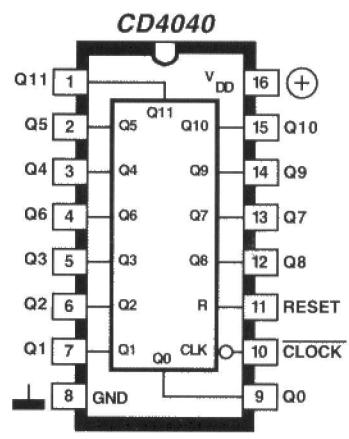
#### TVCHK.EXE

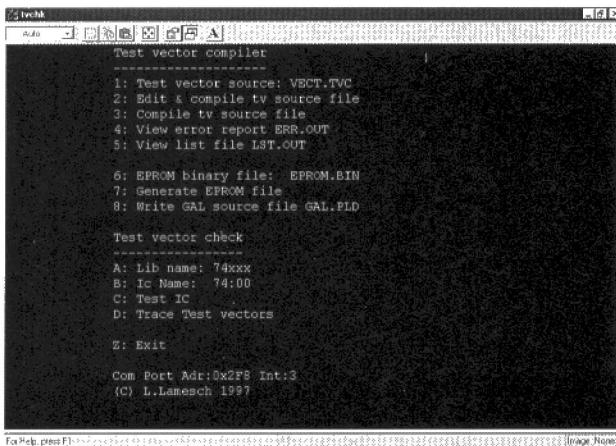
This is a kind of shell program that launches ICTVC.EXE, and enables test vector scripts to be debugged. For this program to operate you have to connect the IC Tester to your PC via the 3-wire serial link. TVCHK should be launched with an appended parameter which is either the COM port number (1-4), or the COM port address (in hex) followed by the associated interrupt line (1-7). Example: TVCHK 2. Obviously, we are talking of the COM port to which the IC Tester is connected! A screendump illustrating some of the options offered by TVCHK is shown in Figure 9.

#### EDT.BAT

This extremely small batch file is used to launch the word processor you will be using to load, modify and save test vector files. If you do not want to employ EDIT.COM, change EDT.BAT as required to make it point to your favourite DOS text editor. Type the name of the file you want to process after 'EDT'. In case 'VECT.TVC' is too large for your wordprocessor, consider creating the part to be appended as a separate file. Once the new test-vector

**Figure 9. Example illustrating the operation of a test vector script. The diagram and the script are all you need to put the 4040 12-bit counter through its paces.**





**Figure 10. The TVCHK program offers a useful shell around the utilities for test vector testing and compiling.**

scripts have been debugged, they may be appended to VECT.TVC without using TVCHK. Next, the option 'Compile tv source' from TVCHK is used to compile the complete file for burning an EPROM.

A good start for practising is the file 'SMALL.TVC'. To get the feel, try replacing 'VECT.TVC' by 'SMALL.TVC' under menu option 2 in TVCHK.

The main menu of TVCHK comprises the following options:

#### Test Vector Compiler

- 1: Test vector source: VECT.TVC  
Indicate name of test vector source file.
- 2: Edit & Compile tv source file.
- 3: Compile tv source file.
- 4: View error report ERR.OUT.
- 5: View list file LST.OUT.
- 6: EPROM binary file: EPROM.BIN

tested/debugged.

#### C: Test IC

This may take a while when many test vectors have to be applied (e.g., more than 10 minutes when testing a script for the 4020).

#### D: Trace Test Vectors

This is the actual debugging tool. For each test vector, the expected logic states and the ones actually measured on the DUT are indicated. Errors are highlighted in red. Pin 1 is always indicated at the left-hand side, and the pin with the highest pin number, at the right-hand side. REPEAT...ENDR loops may be skipped by pressing the 's' key.

#### Z: Exit

Indicate the name of the binary file to be burned into the EPROM.

#### 7: Generate EPROM file.

Remember, the output format is binary!

#### 8: Write GAL source file GAL.PLD.

#### Test Vector

#### Checking

#### A: Lib name: 74xxx

Indicate name of the library containing the test-vector set to be tested/debugged.

#### B: IC name: 74:00

Indicate name of test-vector set to be

Quit the program.

**COM Port Addr: xxx Int: y**

Tell the PC which COM port to use for communication with the IC Tester.

#### LARGER EPROMS

Those of you who wish to add test vector scripts for ICs not supported by the default system EPROM may soon find that the size of the .BIN file generated by TVCHK option '7' exceeds the capacity of a 512-kbit (64-kByte) EPROM like the 27(C)512. That is not a problem, however, because the IC tester hardware accommodates larger EPROMS like the 2-Mbit (256-kByte) 27020 without problems. Because these giant EPROMS are divided into 64-kByte banks, bank-switching then has to be implemented by means of outputs B6 and B7 of PIO device IC2. Address line A17 is then also required, so you have to set jumper JP1 to the 'not-A' position when using a 27C020 EPROM.

#### CONCLUSION

You have been reading an article discussing a test instrument which, in its standard version, allows a vast number of integrated logic circuits from the 74 (TTL) and 4000 (CMOS) series to be subjected to some pretty thorough testing. If you are not satisfied with the range of ICs that can be tested, a number of powerful software tools are available to 'roll your own', just using a common-or-garden PC (running plain old DOS) and, optionally, an EPROM programmer capable of handling EPROMS with a capacity of at least 512 kbytes. Happy testing!

(980029-2)

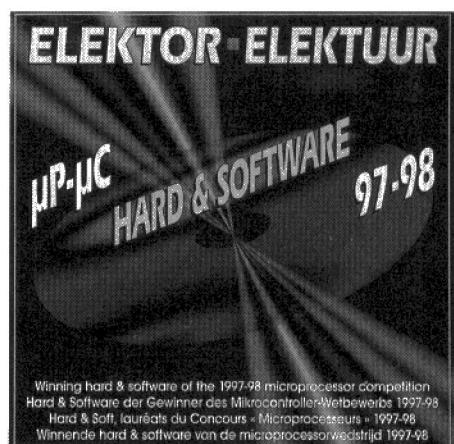
## The 100% DIY approach

Although the best guarantee to successful construction of this project is to order a ready-programmed GAL and EPROM from the Publishers, together with a PCB and a floppy disk (order as a set, order code 980029-C), there are two alternative, cheaper, ways for the more audacious.

The CD-ROM entitled 'μP-μC Hard & Software 97-98' (order code 986001-1) contains THE WORKS, i.e., all files to program your own GAL and EPROM for this project, in addition to the 'master' test vector file, the 535's executable code, source code files in C and assembly language, and all software utilities mentioned in this instalment. So, if you are completely self-supporting, that is, have access to a PC, a GAL programmer and an EPROM programmer, we suggest buying just the PCB and the CD-ROM. The relevant subdirectory on the CD-ROM is /INT. Remember, you can not run the test vector utilities from the CD-ROM since they need to create files!

The second option for the more advanced among you is to buy only the PCB and the floppy disk. The floppy contains a sub-set of the files on the CD-ROM: not included are the assembler files and the PCB artwork and circuit diagrams as originally supplied by the author. For the rest, everything is included to create and debug your own test vector files, and prepare a binary file for burning into an EPROM, as described in this article. The .JED file for programming your own GAL is also included.

Whichever option you choose, remember that any hardware or software component needed to build (and understand) this project is available separately through our Readers Services.



Winning hard & software of the 1997-98 microprocessor competition  
Hard & Software der Gewinner des Mikrocontroller-Wettbewerbs 1997-98  
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Winnende hard & software van de microprocessorwedstrijd 1997-98



# $\mu$ Processor System Hardware

---

## Single IC monitors whole system

A computer system or, indeed, any microprocessor-based system, can operate reliably only when its internal temperature and supply rails are held stable within specified limits. The hardware monitoring of these quantities, and others, is simplified by National Semiconductor's new Integrated Data Acquisition System Type LM78.

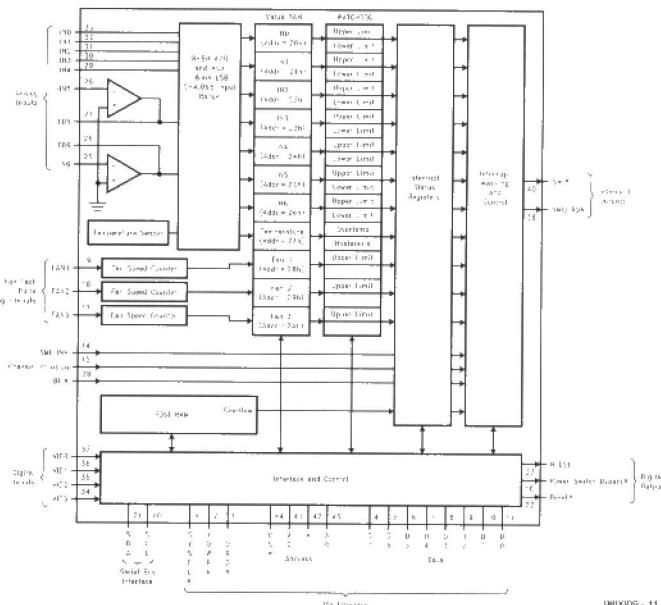
### Features

- ◊ Temperature sensing
- ◊ Five positive voltage inputs
- ◊ Two op amps for negative voltage monitoring
- ◊ Three fan speed monitoring inputs
- ◊ Input for additional temperature sensors
- ◊ Chassis Intrusion Detector input
- ◊ WATCHDOG™ comparison of all monitored values
- ◊ POST code storage RAM
- ◊ ISA and I<sup>2</sup>C™ Serial Bus Interfaces

### GENERAL DESCRIPTION

The LM78 is intended for hardware monitoring of servers, PCs, or virtually any microprocessor-based system. In a PC, the LM78 may be used to monitor power supply voltage, temperatures, and fan speeds. Actual values of these quantities can be read at any time, and programmable WATCHDOG™ limits in the LM78 actuate a fully programmable and maskable interrupt system.

Figure 1. Block diagram of the LM78.



WATCHDOG™ is a trademark of National Semiconductor Corporation

I<sup>2</sup>C™ is a registered trademark of the Philips Corporation

The content of this note is based on information received from manufacturers in the electrical and electronics industries or their representatives and does not imply practical experience by Elektor Electronics or its consultants.

A National Semiconductor Application

with two outputs.

The LM78 has an on-chip temperature sensor, five positive analogue inputs, two inverting inputs (for monitoring negative voltages), and an eight-bit Delta-Sigma analogue-to-digital converter (ADC). See the block diagram in **Figure 1**.

An input is provided for the overtemperature outputs of additional temperature sensors and this is linked to the interrupt system.

The LM78 provides inputs for three fan tachometer outputs. Additional inputs are provided for chassis intrusion detection circuits, VID monitor inputs, and chainable interrupt.

The LM78 provides both ISA and Serial Bus interfaces. A 32-byte auto-increment RAM is provided for POST (Power On Self Test) code storage.

## FUNCTIONAL DESCRIPTION

The LM78 continuously converts analogue inputs to 8-bit digital words with a 16 mV LSB (least significant bit) weighting, yielding input ranges of 0–4.096 V. The two negative analogue inputs provide inverting op amps with their non-inverting input referred to ground. With additional external feedback resistors, these inputs provide measurements of negative voltages (such as -5 V and -12 V power rails). The values of these resistors for a number of voltage measurements are shown in **Figure 2**. The result of the various processes is stored in a bank of registers ( $20_{16}$ – $2A_{16}$ ) which are found under Value RAM in Figure 1. The analogue inputs are useful for monitoring several power supplies present in a typical computer.

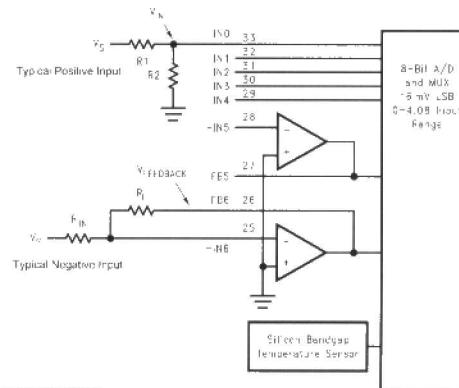
Temperature is converted to an 8-bit two's-complement digital word with a  $1^{\circ}\text{C}$  LSB.

Fan inputs measure the period of tachometer pulses from the fans, providing a higher count for lower fan speeds. The fan inputs are digital inputs with an acceptable range of 0–5 V and a transition level of about 1.4 V. Full-scale fan counts are 255 (8-bit counter) and this represents a stopped or very slow fan. Nominal speeds, based on a count of 153, are programmable from 1100 to 8800 rev/min. Signal conditioning circuitry is included to accommodate slow rise and fall times.

The LM78 provides a number of

**2**

Voltage Measurements ( $V_S$ )	R1 or $R_{IN}$	R2 or $R_F$	Voltage at Analog Inputs
-2.50V	0	NONE	+2.50V
-3.30V	0	NONE	+3.30V
+5V	6.8 k $\Omega$	10 k $\Omega$	+2.98V
+12V	30 k $\Omega$	10 k $\Omega$	+3.00V
-12V	240 k $\Omega$	60 k $\Omega$	-3.00V
5V	100 k $\Omega$	60 k $\Omega$	+3.00V



**Figure 2. Examples of the analogue inputs that monitor the supply rails in a PC. The resistor values shown provide about 3 V at these inputs.**

internal registers as detailed in **Figure 3**. These include

**Configuration Register** providing control and configuration of the chip.

**Interrupt Status Registers**, providing the status of each WATCHDOG<sup>TM</sup> limit or event.

**Interrupt Mask Registers** allowing masking of individual interrupt sources, as well as separately masking each of both hardware interrupt outputs.

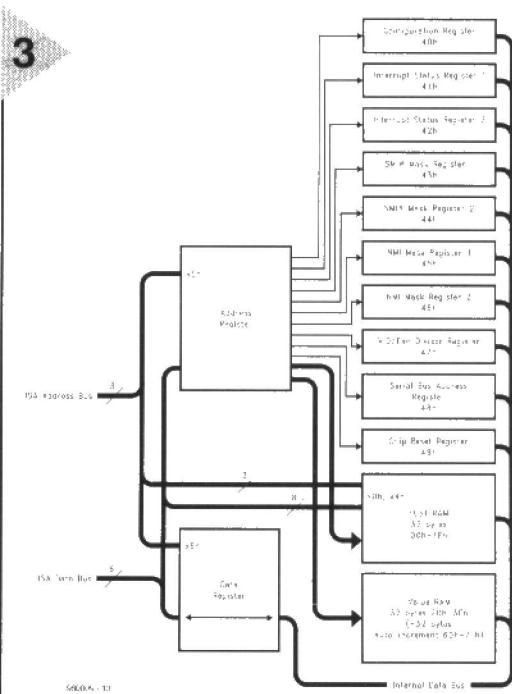
**VID/Fab Divisor Register** for reading the status of the VID input lines. The high bits of this register contain the divisor bits for Fan1 and Fan2 inputs.

**Serial Bus Address Register** which contains the Serial Bus address. At power on, it assumes the default value of 0101101, and can be altered via the ISA or Serial Bus Interface.

**Chip Reset/ID Register** which allows the resetting of all the registers to the default power-on reset value. It provides a bit for identification between the current version of the device and an older version which does not have this reset capability.

**POST RAM**. This FIFO RAM stores up to 32 bytes of 8-bit POST codes. Overflow of this register will set an interrupt. The register, located at base address x0h and x4h, allows

**3**



**Figure 3. Register structure of the LM78. Relevant software sets the limits at which interrupt lines will be set. Monitoring results are easily read.**

## AFFORDABLE BY EVERYONE...

The Studio Lite consists of ULTICap schematic capture, ULTIboard PCB design and ULTRoute GXR autorouter. Both Windows 95 and DOS versions are included in the CD-ROM. Actually you only pay for the 5 manuals! In which, besides tutorials and manuals, even shapes are described! Ideal for hobbyist and study and with sufficient capacity (500 pins). If higher capacity is needed you can opt (now or later) for an upgrade to the Studio Unlimited, without capacity limits, for £ 68 (incl. VAT). There are no further options or hidden extras, the *ULTIboard Studio program is complete!*

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for easy decoding to address 80h and 84h, the normal addresses for outputting of POST codes. Interrupt will be set only when writing to port x0h or x4h is taking place. The register can be read via ports 85h and 86h.

**Value RAM** containing the monitoring results: temperature, voltages, fan counts, and WATCHDOG™ limits. This register consists of a total of 64 bytes. The first 11 bytes are all of the results, the next 19 bytes are the WATCHDOG™ limits, and are located at 20h–3Fh, including two unused bytes in the upper locations. The next 32 bytes, located at 60h–7Fh, mirror the first 32 bytes with identical contents. The only difference in the upper bytes is that they auto-increment the LM78 Internal Address Register when read from, or written to, via the ISA Bus (auto-increment is not available for Serial Bus communications).

When the LM78 is started, it cycles through each measurement in sequence, and it continuously loops through the sequence about once every second. Each measured value is compared to values stored in WATCHDOG™ or Limit registers.

When the measured value violates the programmed limit, the LM78 will set a corresponding interrupt in the Interrupt Status. Two hardware interrupt lines, SMI# (System Management Interrupt) and NMI/IRQ# (Non-maskable interrupt/interrupt request), are fully programmable with separate masking of each interrupt source, and masking of each output. In addition, the Configuration Register has control bits to enable or disable the hardware interrupts.

## INTERFACE

The LM78 decodes only the three lowest address bits on the ISA Bus, resulting in the following base addresses.

- Port x0h: POST codes from the ISA Bus.
- Port x4h: POST codes from the ISA Bus.
- Port x5h: The LM78 Internal Address Register.
- Port x6h: Data Register.

IORD# is the standard ISA Bus sig-

nal that indicates to the LM78 that it may drive data on to the ISA data bus.

IOWR# is the standard ISA command to the LM78 that it may latch data from the ISA Bus.

SYSCLK is the standard ISA system clock, typically 8.33 MHz. This clock is used only for timing of the ISA interface. All other clock functions within the LM78, such as the ADC and fan counters, are done with a separate asynchronous internal clock.

A typical application designed to use the POST RAM would decode the LM78 to the address space starting at 80h, which is where POST codes are output to. Otherwise, the LM78 can be decoded into a different desired address space.

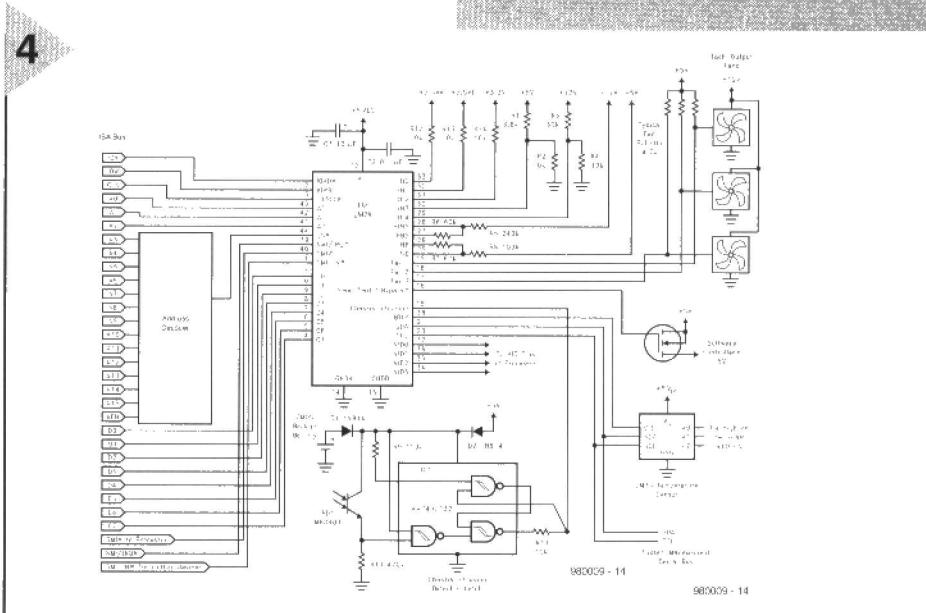
To communicate with an LM78 register, first write the address of that register to Port x5h. Read or write data

ISA is active will not be a problem, since even a single bit of Serial Bus communication requires 10 microseconds, in comparison to less than a microsecond for an entire ISA communication.

## TYPICAL APPLICATION

The setup of a typical application is shown in Figure 4. It monitors temperature, the speed of three fans, and seven power supply voltages. The chassis intrusion detector is based on a photodiode and discrete bistable. When the chassis has been opened

**Figure 4.** In this application, the LM78 monitors temperature, fan speed of three fans, and seven power supply voltages. It also monitors the O.S. output of up to eight LM75 digital temperature sensors as well as an optical chassis intrusion detector.



from or to that register via Port x6h. A write will take IOWR# low, while a read will take IORD# low.

If the Serial Bus interface and ISA Bus interface are used simultaneously, there is the possibility of collision. To prevent this from occurring in applications where both interfaces are used, read Port x5h and if the Most Significant Bit (MSB), D<sub>7</sub>, is high, ISA communication is limited to reading Port x5h only until this bit is low. A Serial Bus communication occurring while

(intruded), the relevant data are stored thanks to a battery backup. The bistable may be reset via the LM78.

A link with the System Management Serial Bus of the PC may be established via the I<sup>2</sup>C™ Bus.

A software-controlled 5 V power supply is provided with the aid of a MOSFET. This supplies the entire circuit, which draws a current of only about 1 mA during normal operation, and about 10 µA in the standby mode.

[980009]

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## PROFESSIONAL HOBBYISTS:

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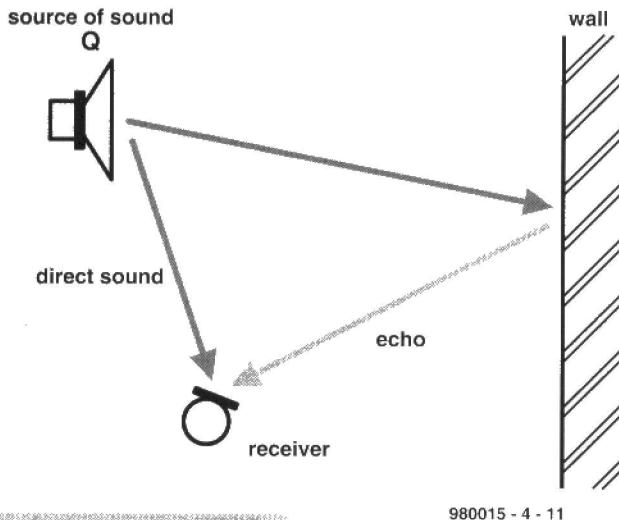
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# introduction to digital signal processing

## Part 4 – From echo to FIR filter

21



980015 - 4 - 11

**Figure 21.** An echo is caused by reflection of the original sound by an object, and is subject to attenuation and delay.

An important function of digital audio signal processing is the generation of reverberation and echo. This instalment looks at how echoes can be generated in a simple manner and how the knowledge gained in this can be put in a general form. These findings lead naturally to digital filters.

By Dr. Ing. M. Ohsmann

attenuation constant and  $s_{k-M}$  is the delayed signal. How can this be arranged as a program? It is clear that to determine signal  $y_k$  at a point in time  $k$ , the input signal  $M$  samples ago must be known. For this, a buffer is required that can hold at least  $M$  sample values. The most appropriate for this is a circulating register in which a data stream circulates in a loop. It is reminiscent of the old echo generators that used an endless magnetic tape for storage. The difference is, however, that in a circulating register the read and write heads move, but not the data as with the endless magnetic tape.

A program (ECHO1.PAS) for  $M=8192$  samples is given in **Figure 2**.

The time delay depends on the sampling rate. If, for example, the rate is 22050 samples/s, the time delay is  $8192/22050 = 0.37$  s. First, listen to the original file WD1R.WAV, then produce it with the instruction

```
ECHO1 \inp=wd1r.wav  
out=tmp.wav
```

and furnish it with an echo that can be heard clearly in file TMP.WAV.

### MULTIPLE ECHOES

A single echo is not often satisfactory. To obtain two or more echoes, the original sound must be combined with a

### SINGLE ECHO

An echo is the repetition of a sound by reflection of sound waves by an object in the path of the original sound. Thus, the reflected sound is identical to the original sound, except for some attenuation and a time delay. If the delay is  $M$  samples long, the received signal is

$$y_k = s_k + as_{k-M},$$

where  $s_k$  is the original sound,  $a$  is the

### Window functions

The frequency characteristic of a digital filter is a periodic function related to the sampling period,  $T$ , which can be expanded as a Fourier series. The coefficients of this series represent the impulse response of the filter. When, in a practical case, this infinite series has to be truncated to  $n$  terms, the sharp cut-off leads to overshoots and oscillations in the characteristic. This is known as the *Gibbs phenomenon* and the effect can be minimized by multiplying the impulse response by a weighting factor described as a *window function*  $w(n)$ . This function can easily be incorporated in the design of an FIR. Some of the common window functions have the mathematical form listed below.

Rectangular	$w(n) = 1$	$0 \leq n \leq (N-1)$
Triangular	$w(n) = 2n/(N-1)$	$0 \leq n \leq (N-1)/2$
Bartlett	$w(n) = 2 - [(2n)/(N-1)]$	$(N-1)/2 \leq n \leq (N-1)$
Hanning	$w(n) = 0.5 - 0.5\cos[(2\pi n)/(N-1)]$	$0 \leq n \leq (N-1)$
Hamming	$w(n) = 0.54 - 0.46\cos[(2\pi n)/(N-1)]$	$0 \leq n \leq (N-1)$

number of reflections that have been delayed by times  $L$  and  $M$ , and attenuated by factors  $a$  and  $b$ .

$$y_k = s_k + a s_{k-L} + b s_{k-M}$$

If still more echoes are desired, use more addends as appropriate. There is a program for this on the CD-ROM entitled FIRFIL1. The true meaning of this name will be revealed later. It enables the computation of echoes in general. The number of echoes required must be specified, together with their time delay and amplitude, by a number in a file. For example, with the file XECHO2.SPP

```
\file 'exec.bat'
firfill\inp=speech1.wav\out=
tmp.wav\filter=fir1.fir
\eof
```

```
\file 'fir1.fir'a simple test filter0
0      0.5
3000   0.4
6000   0.3
12000  0.2
16000  0.1
\eof
```

\end

five echoes are obtained with delay times 0, 3000, 6000, 12000 and 16000 samples long, and amplitudes 0.5, 0.4, 0.3, 0.2, 0.1. The maximum delay is 16383 samples long, and the maximum number of echoes is 1000.

Try these echoes with XECHO2.SPP. In file TMPWAV, a number of beautiful echoes may be heard. The addition of a sufficiently large number of echoes results in reverberation.

## FIR FILTERS\*

The program FIRFIL1 is capable of much more than the generation of echoes. As an experiment, generate a sweep signal and pass it through the filter defined in ECHO3.SPP. This results in 256 echoes with rather unusual values as may be seen on the oscilloscope in Figure 23. This clearly indicates that the sweep signal is passed over a certain frequency range only: that is, the filter is a band-pass section.

Unfortunately, it is not easy to average the sound intensity of 256 echoes in a manner that results in a band-pass function. Before the actual technique is discussed, we will take a look at how finite impulse response (FIR) filters\* function.

A FIR filter that generates echoes with time delays 0, 1, 2, ... and sound intensities  $a_0, a_1, a_2, \dots$  is described by the equation

\* Also known as non-recursive filters or transversal filters.

```
22
program echo1 ;
uses dos,crt,graph ;
{I SIGLIB.PAS }

var k:int;
x,y:float ;
buffer:array[0..8191] of float ;
pointer:int ;

begin
start('simple echo') ;
inp_fn:='tmp1.wav' ; set_par_string('\inp=',inp_fn) ;
out_fn:='tmp.wav' ; set_par_string('\out=',out_fn) ;

open_inp(inp_fn) ;
open_out(out_fn) ;

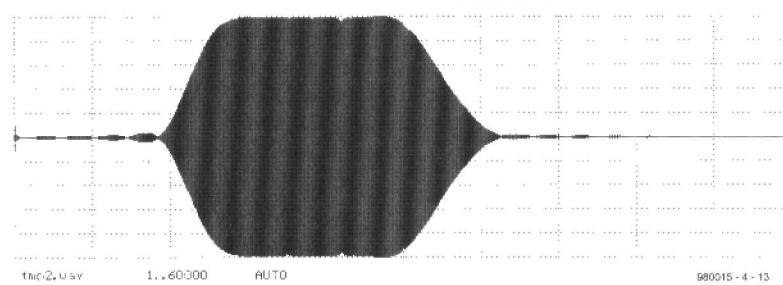
pointer:=0 ;
for k:=0 to 8191 do buffer[k]:=0 ;

for k:=1 to nsamples do
begin
x:=input ;
y:=buffer[pointer] ;
buffer[pointer]:=x ;
pointer:=pointer+1 ;
if pointer>=8192 then pointer:=0 ;
output(x+0.5*y) ;
end ;

stop ;
end.
```

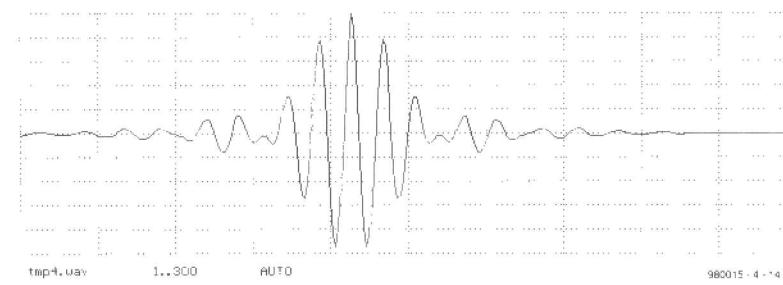
**Figure 22.** Program for generating an echo.

23



**Figure 23.** When a sweep signal is passed through an echo-filter, the result is a band-pass characteristic.

24



**Figure 24.** Impulse response of a band-pass filter.

$$y_k = a_0 x_k + a_1 x_{k-1} + a_2 x_{k-2} + \dots$$

where  $x_k$  and  $y_k$  are the input and output values respectively.

To find the impulse response of the filter, that is, the value of  $y_k$  when  $x_0=1$  and all other values  $x_j=0$ , we must first calculate the value of

$$y_0 = a_0 x_0 + a_1 x_{-1} + a_2 x_{-2} + \dots$$

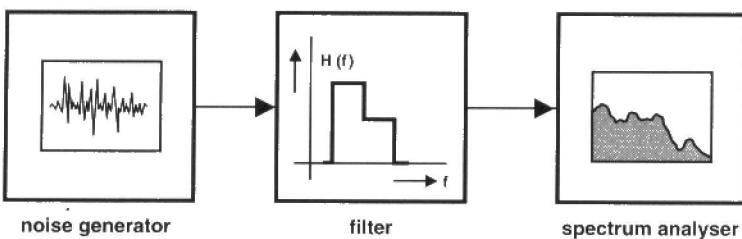
Only the first term remains, so that

$$y_0 = a_0.$$

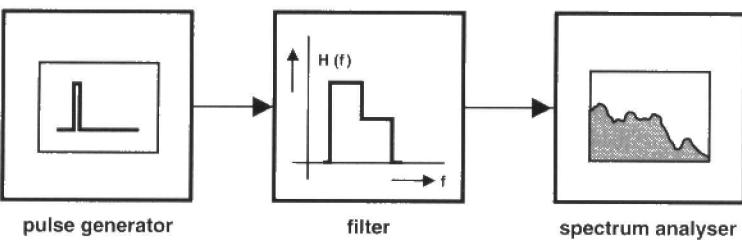
When  $k = 1$ ,

$$y_1 = a_0 x_1 + a_1 x_0 + a_2 x_{-1} + \dots$$

25



**Figure 25. Noise and pulse signals contain all frequencies.**



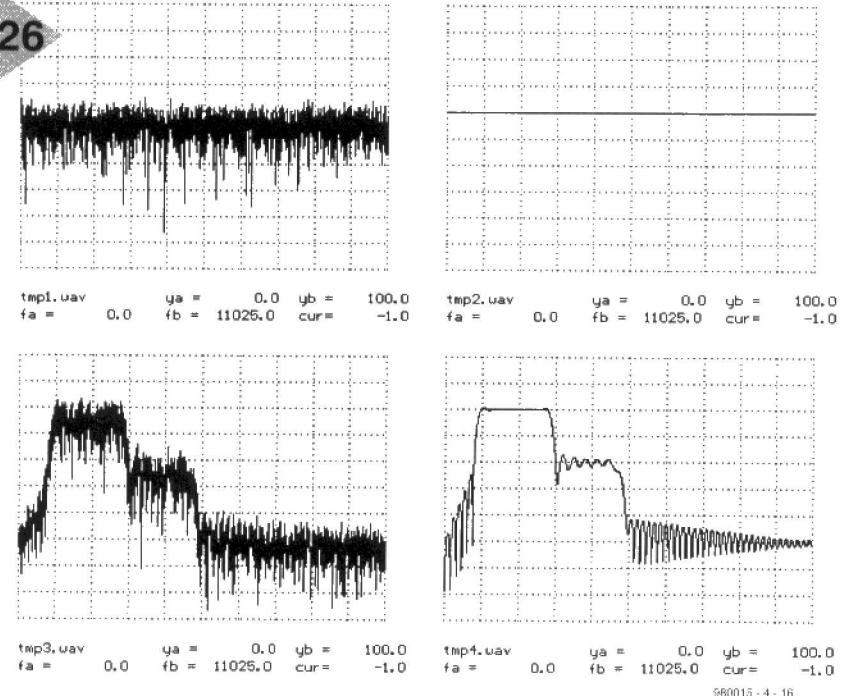
only the second term remains, so that  $y_1 = a_1$ .

Continuing this process shows that for all values of  $k \geq 0$ ,  $y_k = a_k$ . This means that the impulse response is the filter coefficient. In other words, if an impuls is passed through such a filter, the result is the filter coefficient. This is due to the second part of XECHO3.SPP. The impuls response of the filter just discussed is shown in Figure 24. It resembles that of an oscillating circuit. This is to be expected because hardware band-pass filters behave like coupled oscillating circuits.

#### ALL - FREQUENCY SIGNALS

In Part 3, a noise signal was used to determine the frequency response of a filter. This is possible since one of the properties of white noise is that it contains all frequencies at the same amplitude. After the signal has been passed through a band-pass filter (Figure 25 top), all frequencies in the out-

26



**Figure 26. Determining the frequency response with a noise signal (left) or a pulse (right). At the top, the input signals, and below the output signals.**

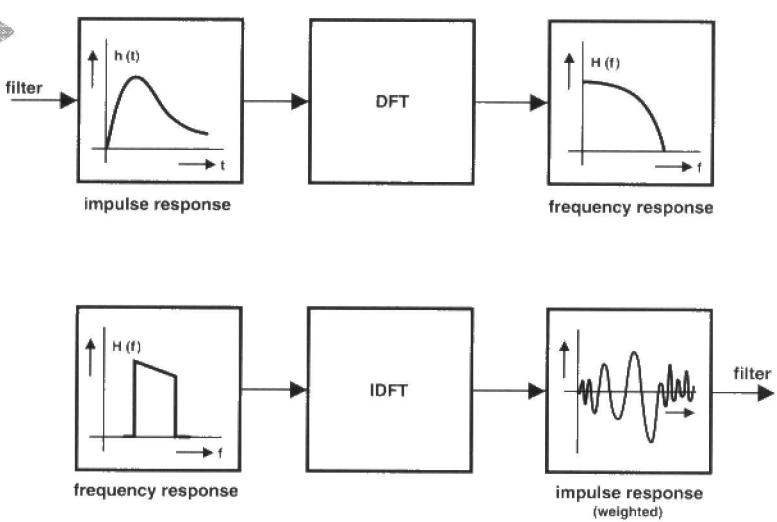
put still have the same amplitude (see Figure 26 left) (Experiment XPULSE1.SPP).

When noise signals are used, arriving at a result through averaging takes a fairly long time. Researchers therefore asked themselves whether there is another kind of signal that gives quicker results and still contains all frequencies. The answer is: yes, a pulse as produced by signal generator PULSE1.EXE.

The spectrum of this pulse shows a virtually constant amplitude for all frequencies (Figure 26 right). Thus, the noise signal used for determining the frequency response may be replaced by a pulse.

A filter reacts to a pulse in accor-

27



**Figure 27. A DFT enables the frequency response to be determined from the impulse response. An IDFT enables the impulse response to be determined from the frequency response.**

dance with its impulse response. This contains all frequencies at the same level as they are passed by the filter, or, in other words, the spectrum of the impulse response is the same as the frequency response of the filter, as shown by tmp3.wav and tmp4.wave in Figure 26. This is an important principle of DSP, which can also be expressed in mathematical terms.

When the spectrum and impulse response are to be determined by a spectrum analyser, the window function (see box) must be disabled to avoid erroneous results. It is important that the impulse response is short enough (here, 4096 samples) to ensure that it fits in the DFT (Discrete Fourier Transform) of the spectrum analyser.

Determining the frequency response of a filter by means of a DFT of its impulse response (see Figure 27) is a fast, simple and accurate method. However, when the frequency response of an amplifier is to be determined, care must be taken to ensure that the input pulses cannot overload the amplifier. If this means the use of low-level pulses, the result may be a very poor signal-to-noise ratio. In such cases, pseudo-noise signals, which have a limited amplitude over the whole frequency range, are often used.

#### FILTER DESIGN

Since the frequency response of a filter may be determined by a DFT of its impulse response, the question arises whether the impulse response can be derived from the frequency response by an Inverse Discrete Fourier Transform (IDFT), to which the answer is: 'yes'. Moreover, when the impulse response is known, the filter may be simulated with the aid of program FIRFIL1.EXE. Filters in digital signal processors are frequently designed in this way.

The design of FIR filters is simplified by program SPECFIL1.EXE. The operation is shown diagrammatically in the lower row of Figure 27. From the frequency response of a filter, its impulse response is determined by an IDFT, which is modified by a window function (see box). This enables the properties of the filter to be fine-tuned. The impulse response of the filter is then written into a file, which processes the FIR program as a data input. A file (XFILDES1.SPP) to compute a simple filter is shown in Figure 28.

The filter specification, the sampling rate, the number of samples in the impulse response, the parameters of the window function, and the value of amplification at the desired frequencies are given in file TMP.FIL. The amplification between the stated frequencies is interpolated linearly as shown in Figure 29.

The result of the program is shown

```

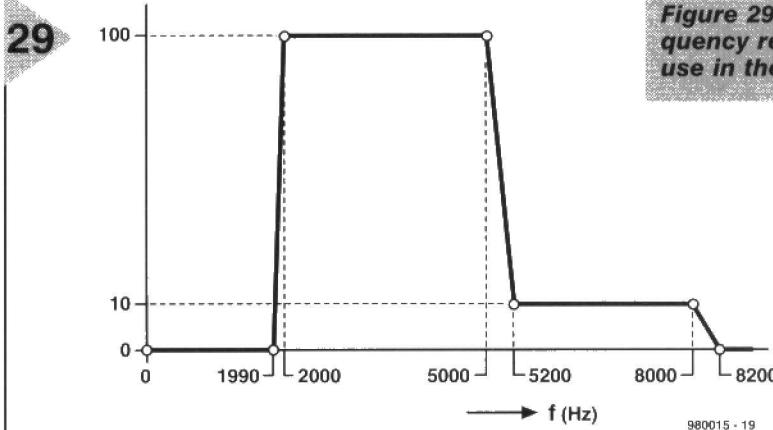
28
\\file 'exec.bat'
\\ generate filter
specfill \filter=tmp.fil \fir=tmpa.fir \bitmap=pic.ps
\\eof

\\ filter specification

\\file 'tmp.fil'
a simple filter as example
normal
44100 ; sample frequency
128 ; number of taps
7 ; alpha for window
7 ; number of data points in frequency domain
0 0
1990 0
2000 100
5000 100
5200 10
8000 10
8200 0
\\eof

```

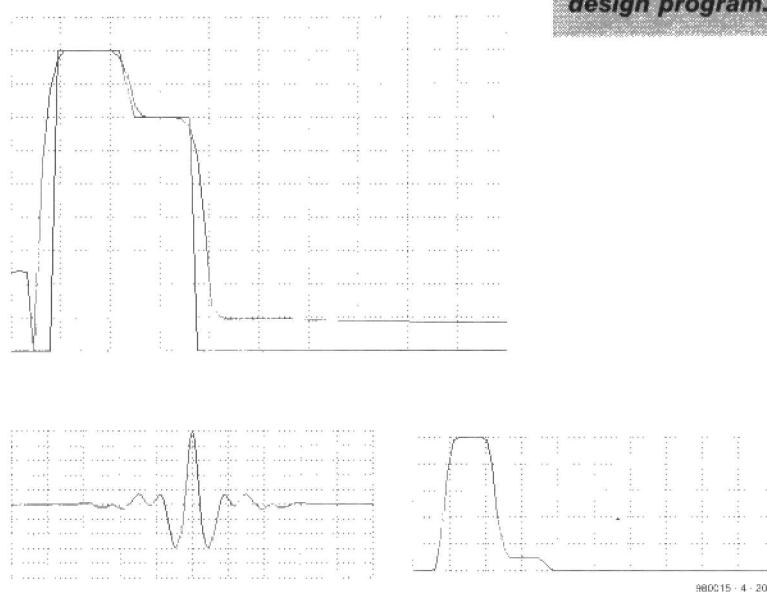
**Figure 28. Data file XFILDES1.SPP**



**Figure 29. Default frequency response for use in the filter design.**

30
n= 128 alpha= 7.0000000 fs= 4.410E+0004  
specification: tmp.fil fir-out to: tmpa.fir

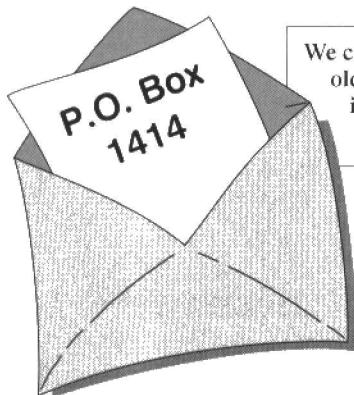
**Figure 30. Screen images of the filter design program.**



in Figure 30. At the top left are the default and actual frequency responses on a logarithmic scale. The impulse response is at the bottom left, and the

frequency response on a linear scale is at the bottom right.

[980015-4]



We can only answer questions or remarks of general interest to our readers, concerning projects not older than two years and published in *Elektor Electronics*. In view of the amount of post received, it is not possible to answer all letters, and we are unable to respond to individual wishes and requests for modifications to, or additional information about, *Elektor Electronics* projects.

## PCB Design System

Dear Editor—I am looking for a PCB design system that allows me to first simulate the electrical operation of a circuit and then use turn the approved circuit diagram into PCB artwork. Having read all reviews and adverts in *Elektor Electronics*, I am none the wiser. Therefore, I am curious to know what software is being used in the *Elektor Electronics* design laboratory.

**T. Will (by email)**

The PCB design process adopted by ourselves is by no means unusual: once a certain software system has been accepted, it is updated and extended whenever necessary, enabling it to grow with our requirements.

In our design lab, the cad age dawned about 10 years ago with the introduction of Ultimate Technology's Ultiboard PCB design program suite. At that time, the dos version was used on at computers. Because Ultiboard was just a PCB design program at that time, a different program had to be used for schematic drawing: Orcad sdt. This combination is still in use as we write this. Pspice has been in use since 1989 for circuit simulation tasks.

The article 'Printed Circuit Board Production' in *Elektor Electronics* November 1994 briefly describes our PCB production process.

## Stereo Microphone Amplifier

Dear Editor—A while ago you published a superb audio A/D converter ('20-bit A/D Converter', December 1996—Tech. Ed.), so I really looked forward to seeing the 'Stereo Microphone Amplifier' (November 1997—Tech. Ed.). I

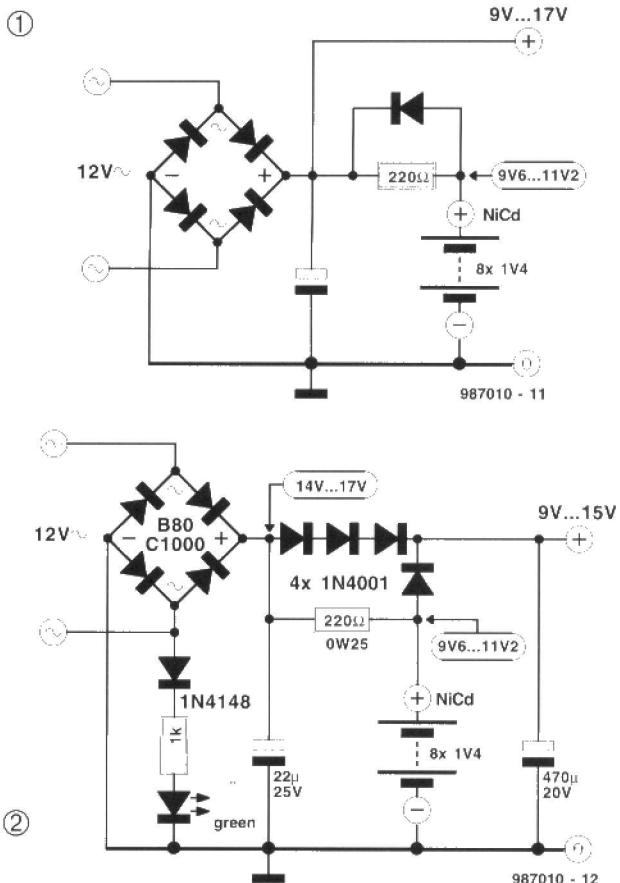
was a little disappointed, however, when I saw the output configuration: unbalanced! I had already omitted the unbalanced input from the A/D converter circuit. How about doing a microphone preamplifier with a balanced input to match the above mentioned converter?

**B. Gillisberger (by email)**

We're pretty sure that the microphone preamplifier meets your demands—it just lacks a balanced output. Enter our SSM412-based converter from the article 'Balanced/Unbalanced Converters for Audio Signals' (March 1998), which offers the perfect solution. Preset P1 is then the equivalent of P1a (or P1b for the other channel) at the output of the microphone preamp. The SSM412 board is conveniently powered by the ±18-volt supply for the microphone preamplifier.

## Diodes instead of a relay?

Dear Editor—Since I was fortunate enough to receive a cordless telephone as my Christmas present, your article 'Uninterruptible Power Supply for Cordless Telephones' came at the right time. Notwithstanding the obvious merits of the circuit, I wish to criticise you on the use of a relay. Are you out of diodes? Normally (circuit diagram no. 1—Tech. Ed.), the battery pack is charged via the resistor. When the mains voltage disappears, the voltage across the reservoir capacitor drops until the diode starts to conduct, eventually enabling the battery to take over. A much smaller reservoir capacitor may be employed because it is no longer necessary to cover the time needed by the relay to change state.



The no-load voltage of 17 V is a bit too high, I think, because the print on original mains adaptors usually reads something like 9.0–15 V. Additional voltage regulation is, however, by no means required because that is usually catered for by the telephone set itself. A couple of diodes are all it takes to replace the (expensive) relay, and an indicator LED is, no doubt useful (circuit diagram no. 2—Tech. Ed.). An alternative would be to use a transformer with a 10-V secondary. However, I realise that the battery charging voltage may then be on the low side.

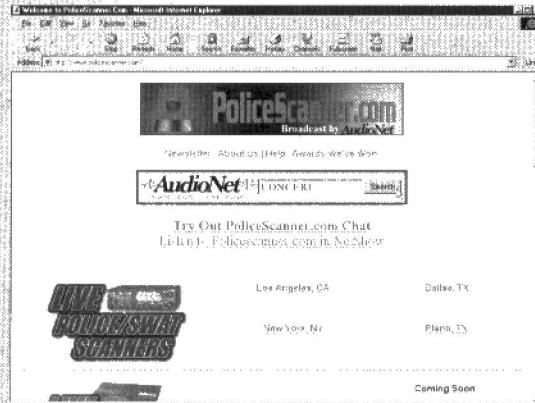
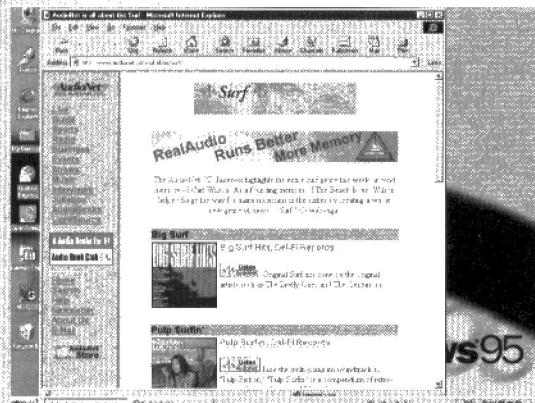
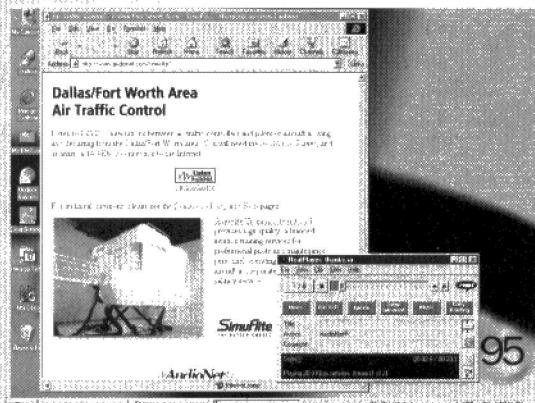
**W. Pressner**

Thanks for your positive criticisms. Even if we do not have enough diodes to start trading, stocks levels easily meet our lab requirements, so that is not the reason for using a relay. The point is that there are always different ways of arriving at circuits with relatively simple functionality. True, the use of a diode is one of the best known solutions to this kind of problem, but it is no more original than a relay. At some moment, the original designer of this circuit, Pradeep G. (a reader of our Indian sister-magazine) decided in favour of the relay-based solution, which works fine, and was no cause for our lab staff to do major revisions on the circuit. Not mentioning the fact that a relay contact does not introduce a serious voltage drop, it has the distinct advantage of electrically disconnecting the telephone from the mains outlet. Surely this has to be a great boon in a country where the mains supply is, at best, unpredictable. The relay does not respond immediately when the mains voltage disappears or returns, the short delay enabling voltage surges to be kept away from the telephone set. Finally, it is our opinion that there is nothing improper about using a relay!

# electronics on-line

## Free radio!

The Radio Caroline's which some of you may fondly remember have been towed ashore and superseded by radio stations not using transmitters at all. The Internet has been discovered as a replacement for those good old radio waves. From now on, free radio will reach you by telephone line.



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The Broadcast Network on the Internet - Microsoft Internet Explorer  
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These days you do not need to have a general coverage receiver anymore to be able to listen to radio stations from distant shores and exotic regions. The modern equivalent of the short-wave receiver consists of an Internet browser, an Internet connection (via an Internet Service Provider) and the so-called RealAudio plug-in module.

An interesting web site demonstrating the many possibilities of webbed radio may be found at <http://www.audionet.com>.

Audionet calls itself 'The Broadcast Network on the Internet'. Its web site provides access to a wide variety of radio programmes and radio services. Using various menus you may choose from sports reports, news, lectures, shows and concerts.

That's not all, however. The web site also offers exclusive services to listeners, like the spoken book and compact disc (CD) listening. Pick a CD title from the stock list, and listen to it via the Internet. Because of the American principle "There Ain't No Such Thing As Free Lunch" (TANSTAF), you will have

to take for granted that each CD is preceded by a 'commercial'. Likewise you can pick a book title, sit back and listen to the book being read to you. The service called AudioBooks at <http://www.audionet.com/#audiobooks> has a number of titles available.

### SCANNER FANS

The above mentioned web site also offers some very 'special' services. For example, Audionet allows you to listen in on certain non-broadcast radio communication channels. For example, the site <http://www.policescanner.com> allows you to eavesdrop on the mobile radio network used by the police in Dallas, New York, Los Angeles or Plano.

Aeroplane spotters are probably more interested in the site <http://www.audionet.com/simufite> which provides a live feed to the Dallas/Fort Worth Traffic Control Tower. In this way, you can listen to communication between Traffic Control and pilots.

### REALAUDIO

If you want to listen to these webbed Free Radio stations, you need to extend the functionality of your Netscape or Microsoft Internet explorer with the Real Audio plug-in. This program, RealPlayer 5, may be downloaded free of charge from <http://www.realaudio.com> after supplying your name and e-mail address.

(98029-1)

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APRIL  
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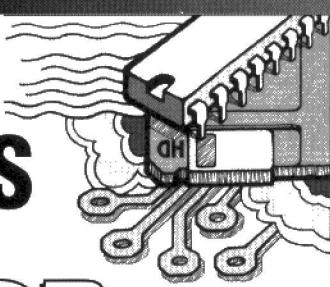
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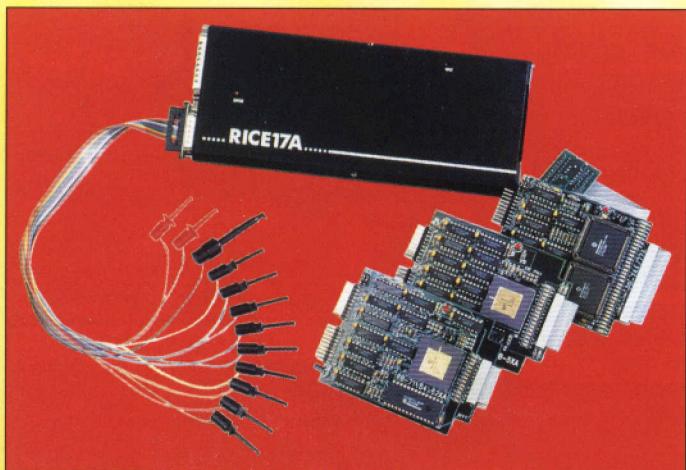
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